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Study of cooking quality of selected varieties of rice at varying temperature using induction heater

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Abstract
Cooking quality was evaluated for four selected varieties of rice (Swarna, Vishnubhog, HMT and Basmati) used in Chhattisgarh state of India. Quality parameters used for this study measured were Optimum cooking time, Water uptake ratio, Grain elongation, Swelling index and Residual solid loss. The results showed that among different varieties of rice, optimum cooking time was maximum for Swarna rice on 300 watt (26.15 min.) and minimum for Vishnubhog rice on 2100 watt (13.43 min.).Water uptake ratio was maximum for Basmati rice on 300 watt (4.27%) and minimum for Vishnubhog rice on 2100 watt (2.84%). Cooking coefficient was maximum for Swarna rice on 1800 watt (7.37) and minimum for Vishnubhog rice on 2100 watt (1.85). Grain elongation was maximum for Basmati rice on 800 watt (0.475) and minimum for Swarna rice on 1600 watt (0.215). Residual solid loss was maximum for Swarna rice on 300 watt (3.2%) and minimum for Vishnubhog rice on 300 watt (1.1%). Swelling index was maximum for Basmati rice on 2100 watt (0.446) and minimum for Vishnubhog rice on 1800 watt (0.3).

Keywords: Cooking coefficient; Grain elongation; Optimum cooking time; Residual solid loss; Water uptake ratio

1. Introduction
Rice is the most important cereal crop used as staple food. It is generally consumed by cooking the whole kernel with water [1]. It contribute 40-80% of the total calorie intake in Asian diet [2, 3]. Study on minimum cooking time showed it range between 10 to 31.67 minutes, with the brown rice cooking is slowest [4].
Priority is given to cooking quality of rice because it is one of the major cereal crop consumed as staple food around the world [5, 6, 7].Consumer preference is based generally on the variety of rice and its origin [8].
Quality of rice also depends upon its variation in genetic and environment where they are grown [9].The value of rice in market depends upon its cooking and processing quality, which can be measured in terms of optimum cooking time, water uptake ratio, grain elongation, residual solid loss**,** swelling index, cooking coefficient etc.
Chhattisgarh, popularly known as “rice bowl”, has a total geographical area 13.6 million ha out of which the total rice grown area is 3.48 million ha with the production of 6.01 million tonnes and productivity of 1730 kg per ha.
In induction cooker, cooking vessel is heated up by magnetic induction. Temperature in induction cooking unit can precisely be controlled by altering the electrical power levels. This system is more energy efficient also because it only heats the vessel kept on it, and not the surrounding air and plate on which vessel is in contact with.

2. Materials and methods
In the present study, four common rice varieties (HMT, Visnubhog, Swarna, Basmati) marketed in Mungeli, Chhattisgarh, India were evaluated for cooking qualities. Precleaning of rice grains prior to the experiment were done manually. Study about the cooking quality of rice at varying temperature was conducted using induction cooker. Cooking was done at induction heater at different power levels. At different power levels, variations in temperature with time were measured and the temperature profile was obtained. Parameters measured for cooking quality of rice were Optimum cooking time, Water uptake ratio, Grain elongation, Residual solid loss**,** Swelling index and cooking coefficient.
Rice was cooked using normal water. The ground water quality parameter of Mungeli, Chhattisgarh is given in table below [10].

Table 1: Ground water quality of Mungeli, Chhattisgarh (India)

Parameter	Mungeli (Chattisgarh)	Standard (ICMAR)
Ph	6.5	6.5-6.8
Turbidity	7.8	5NTU
DO	4.2	4-6 mg/l
BOD	6.5	-
COD	7.5	-
Hardness	271.3	300 ppm
Alkalinity	174	200 ppm
TDS	393	500 ppm

2.1 Temperature profile of water
A stainless steel pan containing 1500 ml of water was kept for heating on induction heater then heat at different power levels (300, 800, 1000, 1300, 1600, 1800 & 2100 Watt).The initial temperature of water was noted. Then variation in temperature of water was recorded using thermometer at every 1 min intervals until it reaches its boiling point. The graph was plotted between times versus temperature at different power levels.

2.2 Various parameters to determine cooking quality of rice
Optimum cooking time
It was determined by boiling 5.0 g of whole rice kernels from each varieties of rice in 20 ml water. Few rice kernels are removed at different time intervals during cooking and pressing them between two transparent glass plates. When the starch is

fully gelatinized, there is no white particle of rice kernel is seen between the glass plates, this time is noted down. This time is called the optimum cooking time for that particular rice variety at that particular power level.

Swelling index

Raw rice of 5gm sample is taken from each variety of rice. Then rice was cooked for optimum cooking time, and then volume of cooked rice is measured after removing gruel from it. Swelling index was calculated as:

$$\text{Swelling index} = \frac{\text{Volume of raw rice}}{\text{Volume of cooked rice}}$$

Cooking coefficient

Length and breadth of 10 selected whole rice kernel from different varieties of rice was taken. These rice were cooked for optimum cooking time. Then average length and breadth of both raw and cooked rice kernel was used for calculation cooking coefficient using following formula:

$$\text{Cooking coefficient} = \frac{Lc - Lr}{Bc - Br}$$

Where

Lc = average length of cooked rice kernel
Lr = average length of raw rice kernel
Bc = average breadth of cooked rice kernel
Br = average breadth of raw rice kernels

Residual solid loss

When rice kernel is cooked little percentage of solids from kernel also gets dissolved in cooking water. Residue of rice kernel solids slowly gets dissolves in cooking water, at the time of cooking process. 5g sample of rice is cooked for optimum cooking time and water collected is drained out in a separate jar. The sample of 2 ml of this aliquot is taken in petri dish and placed in a hot air oven at 100 ˚C. Sample is heated till its weight becomes constant, which means all water present is evaporated. Then the Petri dish is taken out and cooled in a desiccators then its weight is recorded. This weight of residue is divided by sample taken is petridish (here 2 ml) gives the residual solid loss.

$$\text{Residual solid loss} = \frac{\text{Wt.of residue}}{\text{Wt.of sample}} \times 100$$

Water uptake ratio

This is determined by taking a sample of 2.0 g of whole rice kernel from each varieties of rice. Then weight of uncooked rice is taken from each samples. Then samples are cooked for optimum cooking time of that particular variety of rice. The excess water is drained off from the cooked rice sample and filter paper was used to soak excess water from it. The water uptake was calculated as ratio of weight of cooked rice and weight of uncooked rice [11].

$$\text{Water uptake ratio} = \frac{\text{Wt.of cooked rice}}{\text{Wt.of uncooked rice}}$$

Grain elongation during cooking

Grain elongation shows the increase in length of rice kernel after cooking. This was measured by taking the average grain length of 10 nos. of whole rice kernel before cooking (L_0) and after cooking at optimum cooking time (L_1). Grain elongation after cooking was calculated as follows:

$$\text{Grain elongation} = L_1 - L_0,$$

Where,

L_0 = average grain length before cooking,
L_1 = average grain length after cooking.

3. Results and Discussions

Most of the cooking quality (optimum cooking time, water uptake ratio, cooking coefficient, grain elongation, swelling index, residual solid loss) which indicates that efforts aimed at selecting rice varieties with improved cooking quality of the rice grain. Hence, this study will help in selecting variety with improved cooking quality for various rice processing and the results of the study are given below. The rice cooking quality characteristic evaluated include optimum cooking time, water uptake ratio, grain elongation, cooking coefficient, residual solid loss and swelling index and the results obtain are shown in figure 1-6. When rice cooking begins it starts to absorb water and it expands in both directions. Length wise increase is desirable; therefore length wise increase should be relatively higher than width wise increase in a high quality premium rice. Water absorbing properties of rice is also affect other cooking quality of rice like swelling index, cooking coefficient and grain elongation as these parameters are also related to change in physical property.

3.1 Temperature profile

It is the profile of induction heater in which we determined, how the temperature varies on different watts of induction heater. At different power levels of 300 Watt, 800 Watt, 1000 Watt, 1300 Watt, 1800 Watt and 1000 Watt variations in temperature of water with time was measured and temperature profile was obtained & was presented in Fig. 1. Time taken to reach 100°C at different power level was 9.21, 9.56, 11.55, 12.13, 13.05, 14.08 & 15.1 minutes at 2100, 1800, 1600, 1300, 1000, 800 & 300 Watt respectively. It is also clear from the result that at higher power level it takes less time to reach higher temperature compared to the subsequent lower power level.

At higher power level water is boiled immediately as there is tremendous stirring of water due to air bubbles. During cooking processes these stirring mechanism affects the cooking quality of rice due to uneven heating of rice, movement of rice in different layer from bottom to top, and change in rate of evaporation.

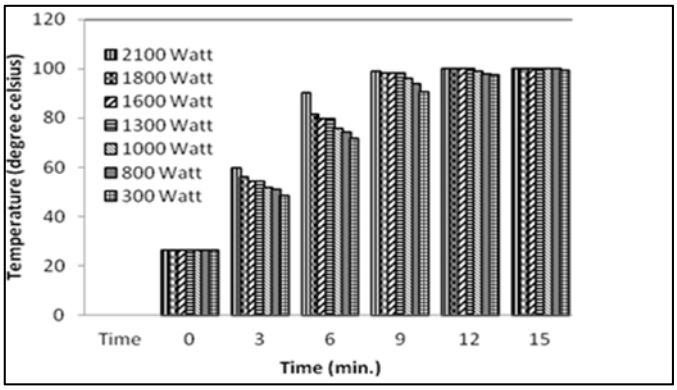

Fig 1: Variation of Rate of rise in temperature with time at different power levels

3.2 Cooking quality of rice

Optimum cooking time

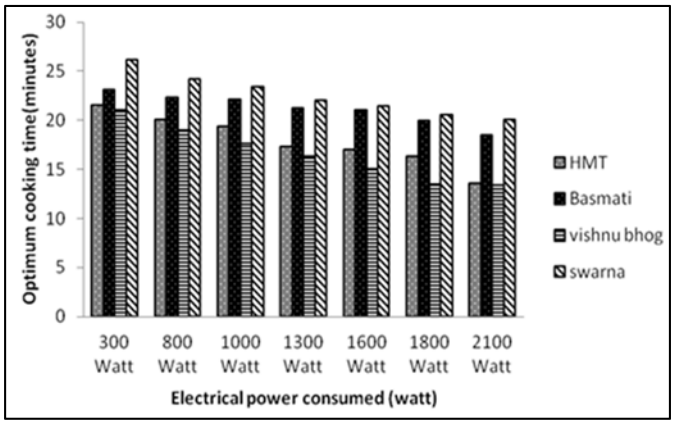

Fig 2: Variation of Optimum cooking time for different rice varieties at different power levels

The rice whose optimum cooking time is less means it cooks quickly as well as it consumes less electricity. Among selected varieties of rice and in different power levels as shown in the Fig. 2, Swarna and Basmati variety of rice shows optimum cooking time higher then HMT and Vishnubhog, which means that swarna and Basmati rice takes longer time to cook than HMT and Vishnubhog. For all varieties at 2100 watt the optimum cooking time was minimum, while at 300 watt the optimum cooking time was maximum. The values of optimum cooking time is minimum for HMT i.e. 13.55 min. Followed by 18.15 min, 13.43,20.1 min for Basmati, Vishnubhog and Swarna respectively at 2100 Watt of power level. The higher the power level, the quicker the water temperature raises results in rice gets cook fast.

Water uptake ratio

The weight of rice increases after cooking is due to water absorption by it during cooking process. Some variety absorbs more water while some absorb less water. The Variation of Water uptake ratio for different rice varieties at different power levels has been presented in Fig. 3. Results show that the water absorption is highest for Basmati rice following HMT, Swarna and Vishnu Bhog respectively. Water uptake ratio is higher at lower power level which diminishes as the power level increases for all varieties of rice.

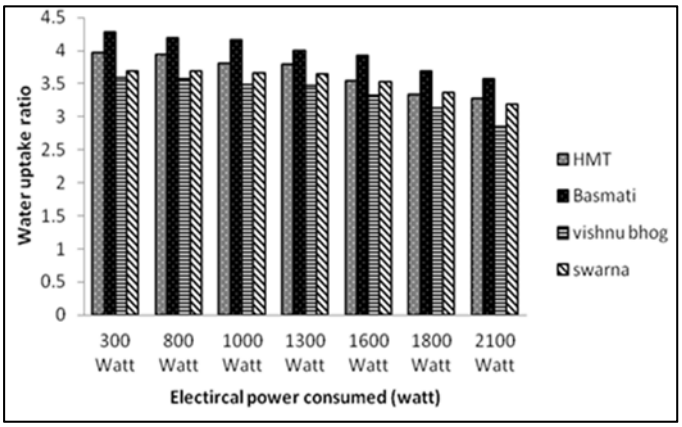

Fig 3: Variation of Water uptake ratio for different rice varieties at different power levels

Cooking coefficient

Cooking coefficient shows ratio of length and width wise expansion after cooking. If cooking coefficient is higher means either its length expansion is more or its width expansion is less, after cooking. From the Fig. 4, it can be shown that Swarna and HMT shows higher cooking coefficient while Vishnu Bhog and Basmati shows lower cooking coefficient. Cooking coefficient is lowest for Vishnu Bhog at all power levels followed by Basmati. Cooking coefficient is highest for Swarna at 1800 Watt.

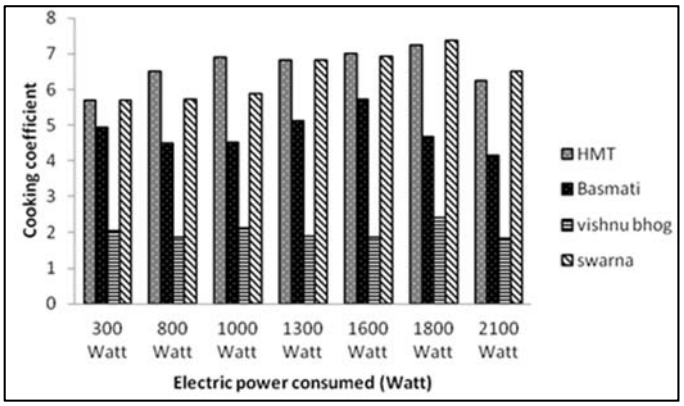

Fig 4: Variation of cooking coefficient for different rice varieties at different power levels

Grain elongation

The dimensional change undergone by rice kernel during cooking process is presented in Fig 5. During cooking process rice absorbs water, due to which its volume increases in length wise and breadth wise. The rice which increases in length after cooking with comparatively less increase in width is generally considered as high quality rice [1].

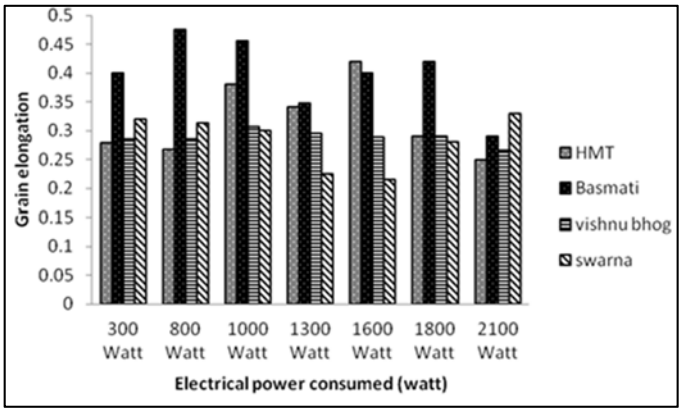

Fig 5: Variation of Grain elongation for different rice varieties at different power levels

Grain elongation shows how much length rice kernel increased after cooking. Among different varieties of rice and at different power level grain elongation is highest for Basmati at 800 Watt and lowest for Swarna at 1600 watt. Grain having higher elongation is desirable as it is mostly preferred by consumers. Highest grain elongation for Vishnu Bhog is at 1000 Watt and for HMT it is at 1600 Watt.

Swelling index

Swelling index shows the volumetric increase of rice after cooking. The lowest the value of swelling index, the higher the

volumetric increase of cooked rice. Swelling index does not show the direction of expansion whether, length wise or width wise. From the Fig. 6, it can be inferred that Vishnubhog shows the lowest swelling index in all power level except at 1600 Watt, where swarna has the lowest swelling index. Basmati shows the highest swelling index at all power level.

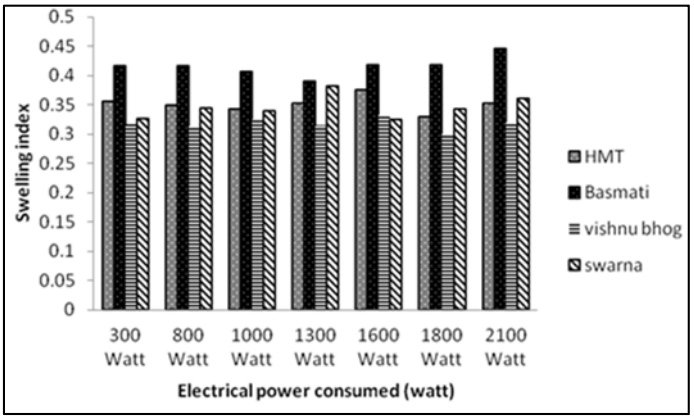

Fig 6: Variation of swelling index for different rice varieties at different power levels

Residual solid loss

Residual solid loss indicates the percentage of rice kernel solid, dissolved in water. It should not be higher as it indicates the loss of grain kernel particles in the water, as a gruel. This gruel is generally disposed after cooking. The variation of Residual solid loss for different rice varieties at different power levels is shown in Fig. 7. From the figure, it can be inferred that Residual soil loss is highest for Swarna at all power level while it minimum for Vishnubhog, except at 1800 Watt where it is also lowest for HMT. Solids from rice kernel gets dissolve into the water due to rice kernel consistency. The process affects the stability of cooked rice.

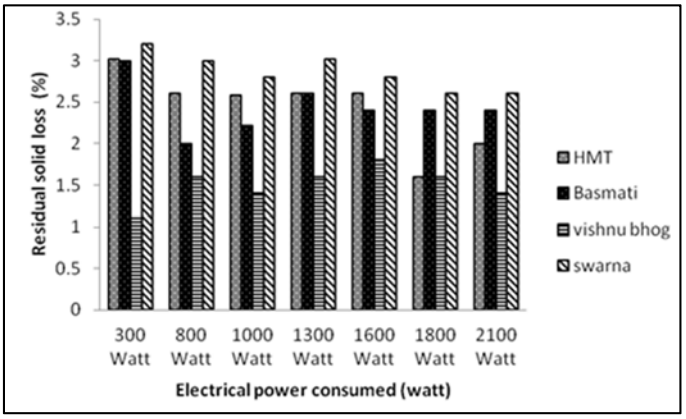

Fig 7: Variation of Residual solid loss for different rice varieties at different power levels

4. Conclusions

Each rice variety shows different cooking characteristics. According to its characteristic, its suitability for different processing operation can be find out. Optimum cooking time was maximum for swarna rice on 300 watt (26.15min.) And minimum for vishnubhog rice on 2100 watt (13.43min.).Water uptake ratio was maximum for basmati rice on 300 watt (4.27%) and minimum for vishnubhog rice on 2100 watt (2.841%).Cooking coefficient was maximum for swarna rice on 1800 watt (7.368) and minimum for vishnubhog rice on 2100 watt (1.847).Grain elongation was maximum for basmati rice on 800 watt (0.475) and minimum for swarna rice on1600 watt (0.215).Residual solid loss was maximum for swarna rice on 300 watt (3.2%) and minimum for vishnubhog rice on 300 watt (1.1%).Swelling index was maximum for basmati rice on 2100 watt (0.446) and minimum for vishnubhog rice on 1800 watt (0.3).

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