Original Research Article

Time - Temperature Combination of Ohmic Heating Systemfor Parboiling of Paddy

ABSTRACT

Parboiling of paddy is carried out in three steps, i.e. soaking, steamingand drying.Parboiling of paddy is a hydrothermal treatment, given prior to milling of paddy. Breakage during milling can be reduced and nutrients preserved in rice grain by prior gelatinization of starch.Parboiling of paddy results in reduction of breakage. The most advantageous aspect of parboiling is the increase in the head yield of rice.

The temperature and time profiles of parboiling of paddy with respectto voltage were studied by recording thetemperature and time at voltage gradients15.71, 16.07, 16.43, 16.79 and 17.14 V/cm during the ohmic heating process. Typicaltemperature profiles at five different voltage gradients15.71, 16.07, 16.43, 16.79 and 17.14 V/cm up totemperature of 96°C for paddy and water mixture of 1:3, (500 g paddy and 1500 ml water) was used for one experiment in theohmic heating cylinder chamber andthey are graphically represented in Fig. 3to Fig. 7,respectively.Time and temperature profiles indicated that with the increase in voltage gradient, temperature was increased, and the parboiling time of samples was reduced meaning thereby that the slope of curve for higher voltage was steeper than the slope of curve for lower voltage.

Keywords:***Parboiling of paddy, Time, Temperature, Voltage Gradient, Regression curve***.

1. INTRODUCTION

The term parboiling means partial cooking of rice within the husk. Parboiling isa hydrothermal treatment. Parboiling of paddy is carried out in 3 steps, i.e. soaking,steaming, and drying.In the soaking process void spaces in the rice kernel are filled with water. Starch granules absorb water and swell causing an increase in the volume of paddy [1]. During steaming, soaked paddy is exposed to heat for a given duration so that the starch present in the rice kernel gets gelatinized. During the gelatinization process starch swells and fills the voids. starch gelatinization during parboiling process is limited by the reaction of starch below 85°Ċ and by diffusion of water above 85°Ċ. In heating, the energy weakens the granule structure and more surfaces become available for water absorption [2].

1.1. Principle of ohmic heating

An ohmic heater is an electrical heating device that uses a liquid's own electrical resistance to generate the heat. Ohmic heating works on the principle of Ohm's law of electricity [3]. The passage of electric current through an electricity conductive food material obeys Ohm's law and heat is generated due to electrical resistance of food.

$$V \propto I$$

$$\mathbf{V = IR} \quad \text{......................eq.1}$$

Where, V = Voltage (volt),
I = Current (ampere),
R = Resistance (Ohm)

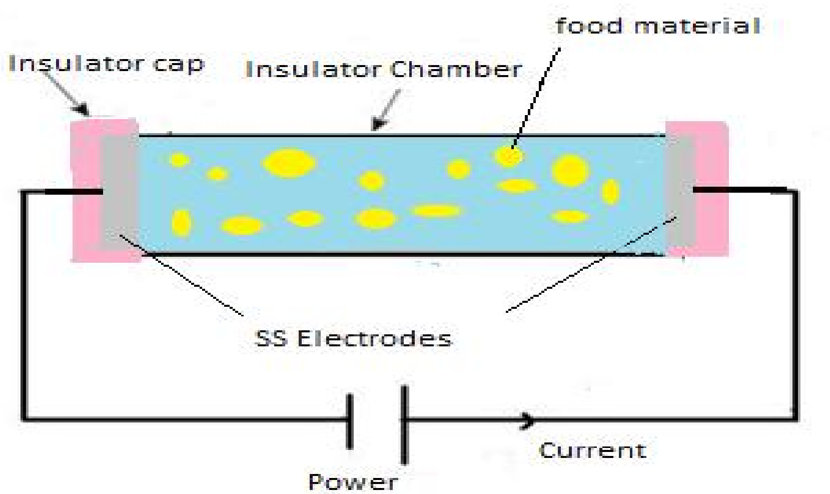


Plate.1 Principle of ohmic heating

Ohmic heating is one of the excellent alternative methods of heating, this technique shows much promise especially in food industry over the last few decades, because there is an increasing shift from batch thermal operation towards continuous high temperature and short time processing of foods [4].

In the traditional parboiling plant steaming process of soaked paddy is carried out in parboiling tank by direct injection of steam generated in the steam boiler which is fitted outside the rice mill in utility section. Boiler unit consists of boiler, fuel tank, water tank, economizer, air preheater, mounting accessary, water supply, insulated piping from boiler up to parboiling tank [5]. The entire boiler unit needs separate care and for this purpose a certified boiler operator with helper needs to be maintained and paid throughout the year, which adds to the processing cost of parboiling rice [6]. If this heating system may be replaced with ohmic heating system, then it will be possible to simply attach two electrodes on the two opposite faces of parboiling tank which will help in resistance/ohmic heating of entire mass of paddy soaked in water housed inside the parboiling tank [7].

Therefore, in this study an experimental set-up of ohmic heating was developed for parboiling of paddy.

2. MATERIAL AND METHODS

This chapter deals with the description of theoretical consideration, engineering principal, materials used, experimental plan and description of device and instruments, to achieve the objective of the present investigation. The present research work on **"Investigation on Application of Ohmic Heating for Parboiling of Paddy"** was undertaken in the Department of Post-Harvest process & Food Engineering, College of Agricultural Engineering, JNKVV, Jabalpur.

In the present study an experimental set-up of ohmic heating was developed for parboiling of paddy in Department of Post Harvest Process and Food Engineering, College of Agricultural Engineering, JNKVV, Jabalpur. In the experimental set-up (T-type) PVC pipe of 29 cm length from end cap to end cap, 19 cm height of 'T' of the PVC pipe, 10.75 cm diameter and 2.5 mm thickness has been selected for construction of the ohmic heating chamber [8]. Stainless steel (SS), rod with 1.2cm diameter and 10cm length was selected as electrode material because of its accuracy and suitability are good for food products. The distance between two electrodes has been kept as 14cm to pass maximum voltage gradient of 17.4 V/cm from Indian domestic supply of 240V. To avoid unforeseen accidents, three insulator caps, made of PVC plastic were provided at three ends of T-shape container. One cap in vertical end of container is removable, when material was fed or removed from the container. Other two-insulator caps were fixed in both horizontal ends with electrodes. The copper coated (PT-100) temperature sensor was used to sense the temperature of 0-200 ^{0}C is placed at the centre of the heating chamber to control the temperature during ohmic heating [9]. The multi-function meter was used in ohmic heating system for monitoring the input voltage, ampere and frequency (Hz.) of the current and it is directly connected to the main source of the current and display all readings time to time during the processing of material. The wooden platform of ohmic heating system having 61cm width and 61cm length for supporting the whole ohmic heating system or also for supporting of metal stand having 26cm height including with 10cm clamp for holding the heating chamber of ohmic heating system [8,9,10].

The experimental set-up of ohmic heating (Plate 2.a and b) was fabricated, for parboiling of paddy.

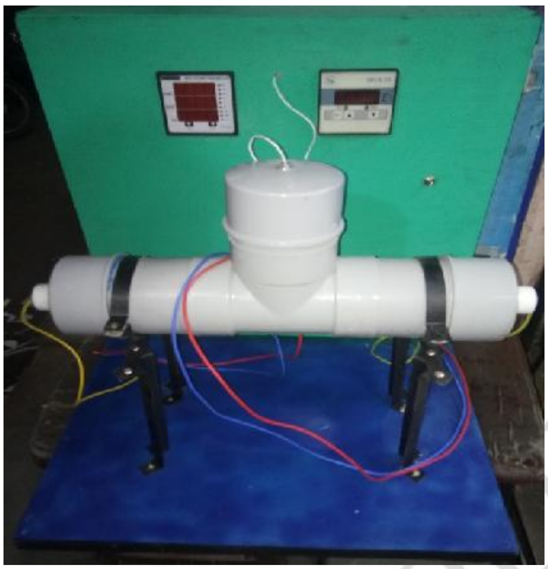
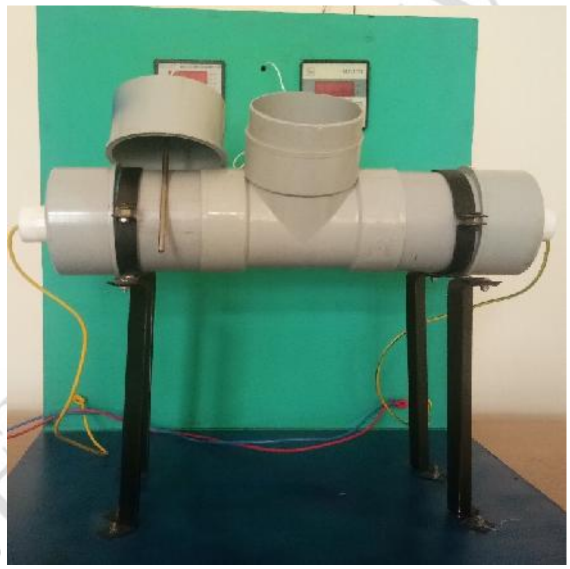
	

Plate 2.a Experimental set-up	**Plate 2.b** Temperature sensor with cap

2.1. Selection of variables

Input voltage gradients15.71, 16.07, 16.43, 16.79 and 17.14 V/cm andat the temperature of 96^{0}C were taken as independent variables, where-as milling quality of parboiled paddy and process time during parboiling of paddy were considered as dependent variables [11].

2.2. Preparation of raw material

Selection of the 10 kg paddy as a sample of MTU1010, one of the most important variety which is grown in central part of India (Madhya Pradesh), was used in the study. Freshly harvested paddy grains were obtained from Directorate of Farms, JNKVV, Jabalpur, Madhya Pradesh, India.10 samples of 500g paddy were used in the setup for parboiling of paddy [12].

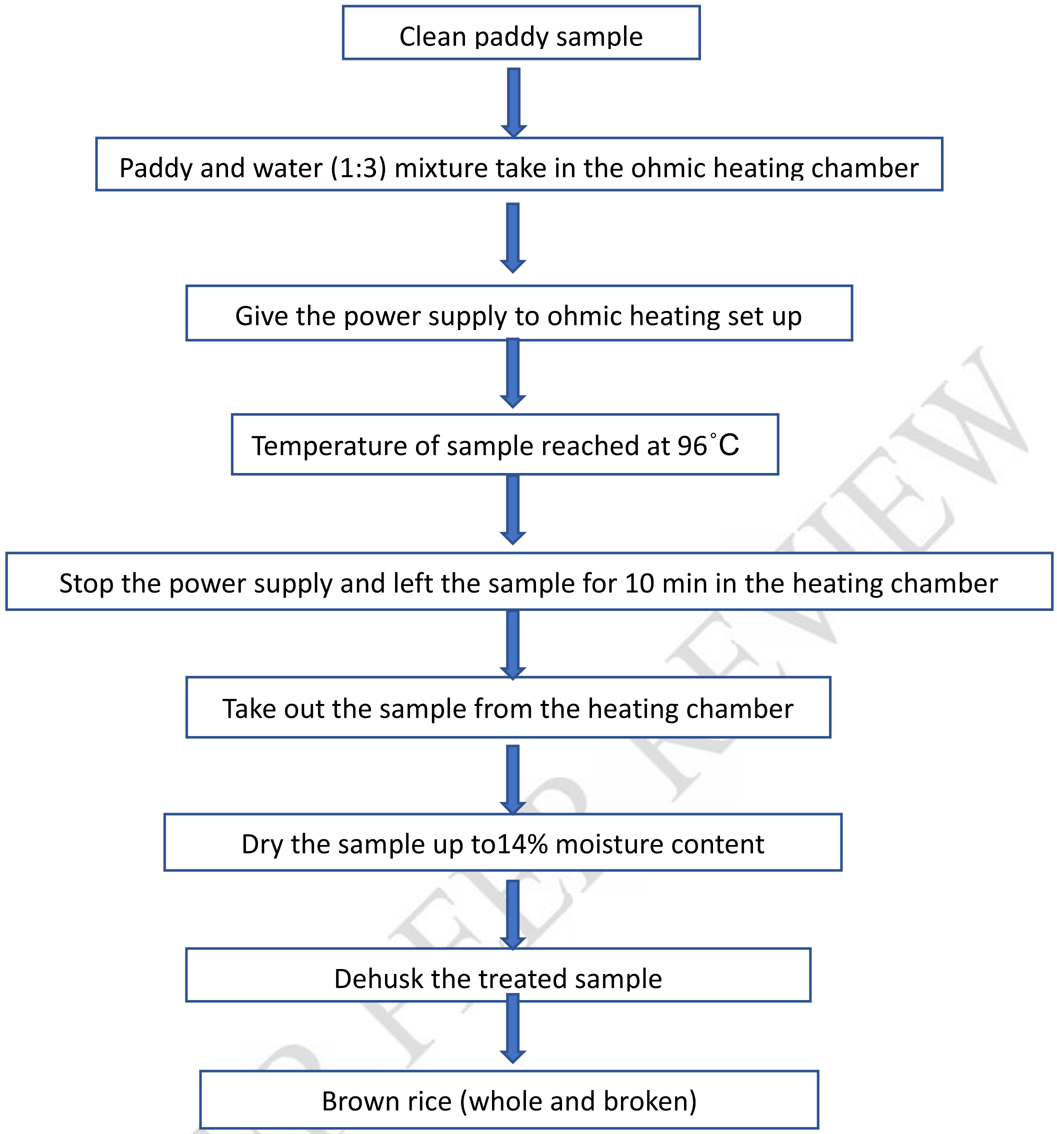


Fig 1. Process flow for paddy processing; parboiling, drying and milling

2.3. Process of parboiling

During the parboiling process, 10 sampleswere selected for the process and each sample was fed into ohmic heating chamber, where a ratio of 1:3 was maintained for paddy and water. Now the power was supplied to ohmic heating system,observations were recorded at voltage gradients of 15.71, 16.07, 16.43, 16.79 and 17.14 V/cm in the ohmic heating chamber at the time interval of 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160 170 and 180 min in the T type PVC ohmic heating chamber (plate no.3). Time required in attaining the temperature of 96˚C for parboiling of paddy was noted and then power supply was switch off and the sample was left in the ohmic heating chamber for 10 min [13]. Paddy was taken, and the remaining water was drained out and two observations were recorded at each voltage gradient, after parboiling of paddy by ohmic heating, first sample was sun dried for 1 hour and then shade drying was performed and the second sample was sun dried for five hours and then kept for shade drying [14].

Plate 3. Parboiled paddy with water mixture.

Samples were dried at 14% mc (wb) before taking it to milling. Milling was done for the treated paddy at the final stage of the process.

Plate 4. Dried ohmic heated parboiled paddy sample

Now the output of milled paddy as received from different openings (Husk, Broken and head rice) were collected and analysed as well as compared with result of milling raw rice under similar milling conditions and the results were compared and tested to evaluate the effects and benefits of ohmic heating system [15].

Plate 5. Brown head rice of ohmic heated parboiled paddy

3. RESULTS AND DISCUSSION

Ohmic heating technology is the most importanttechnology for the research purpose,professionalism and widely used for foodprocessing industries because of its advantagesover conventional heating technology.Researchers and food processing industriesfound superior quality product with minimalnutritional or quality degradation after using theohmic heating technology. Its allow uniform andfast heating, simple process and designing ofohmic heater is also relatively a simple task.

3.1. Parboiling of paddy by ohmic heating

The temperature and time profiles of parboiling of paddy with respectto voltage were studied by recording thetemperature and time at voltage gradientsof 15.71, 16.07, 16.43, 16.79 and 17.14 V/cm during the ohmic heating process. Typicaltemperature profiles at five different voltage gradientsof 15.71, 16.07, 16.43, 16.79 and 17.14 V/cm up totemperature of 96°C for paddy and water mixture of 1:3, (500g paddy and 1.5 litre water) was used for one experiment in the PVC ohmic heating cylinder chamber and are graphically represented in Fig. 2 to Fig. 6,respectively. All the graphs shown in the figures could be expressed in theform of linear regression equation:

$$Y = a + bx \qquad \text{……………….eq. 3}$$

where,

Y = Temperature generated during ohmic heating for parboiling of paddy, °C

x = Time, min.

b = Slope (Rate of heating, dy/dx), °C/min

a = Regression coefficient

3.2. Relationship between time and temperature at voltage gradient of 15.71V/cm,

The fig. 2, 3, 4, 5 and 6show the relationship between time taken to reach thetemperature of 96˚C for parboiling of paddy and at voltage gradient of 15.71, 16.07, 16.43, 16.79 and 17.14 V/cmV/cm. Fig. 2, 3, 4, 5and6 clearly depict that the temperature increased with increase in time. In this experiment time required in

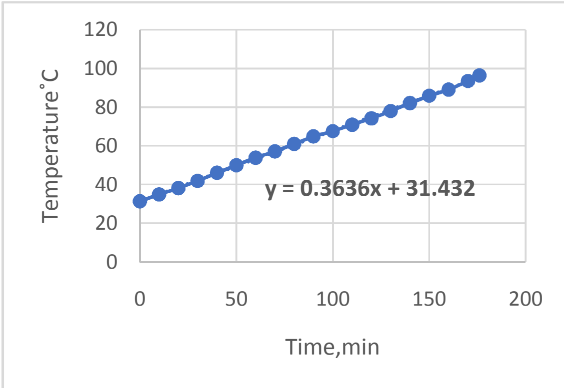


Fig.2. Temperature of 96˚C at voltage gradient of 15.71V/cm for 176 min.

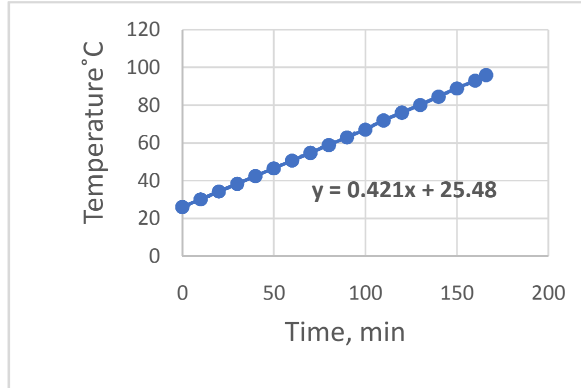


Fig.3. Temperature of 96˚C at voltage gradient of 16.07 V/cmfor 166 min.

attaining the temperature of 96˚C for parboiling of paddy was 176, 166, 156, 146 and 136 mins respectively and then power supply was switch off and the sample was left in the ohmic heating chamber for 10 min. Now two observations were recorded after parboiling of paddy by ohmic heating, first sample was sun dried for 1 hour and then shade drying was performed and the second sample was sun dried for five hours and then kept for shade drying. For this experiment linear regression equation exhibiting the time-temperature relationship was

Y = 0.3636x + 31.432…………..eq.3

Y = 0.4211x + 25.488 …………..eq.4

Y = 0.454x + 23.96 …………..eq.5

Y = 0.5018x + 21.324 …………..eq.6

Y = 0.5493x + 21.152…………..eq.7

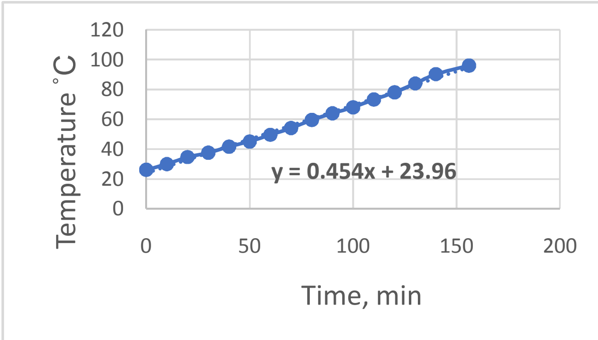


Fig.4. Temperature of 96˚C at voltage gradient of 16.43 V/cm for 156 min.

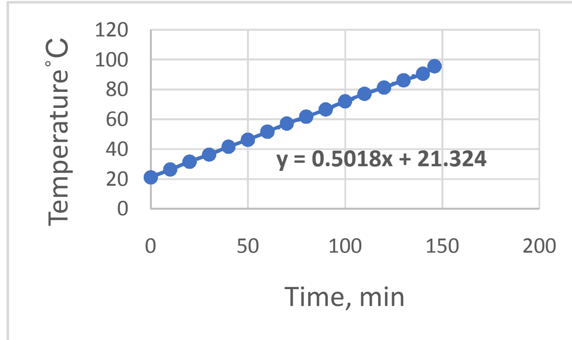


Fig.5. Temperature of 96˚C at voltage gradient of 16.79 V/cm for 146 min.

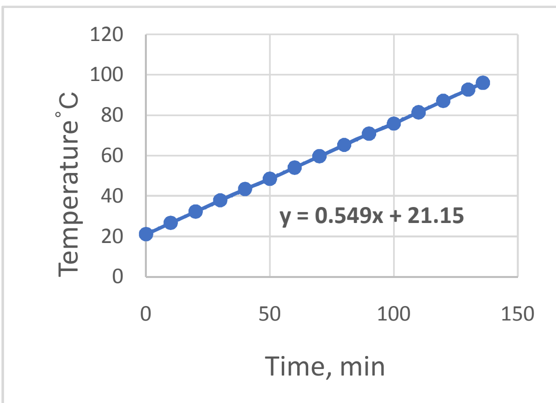


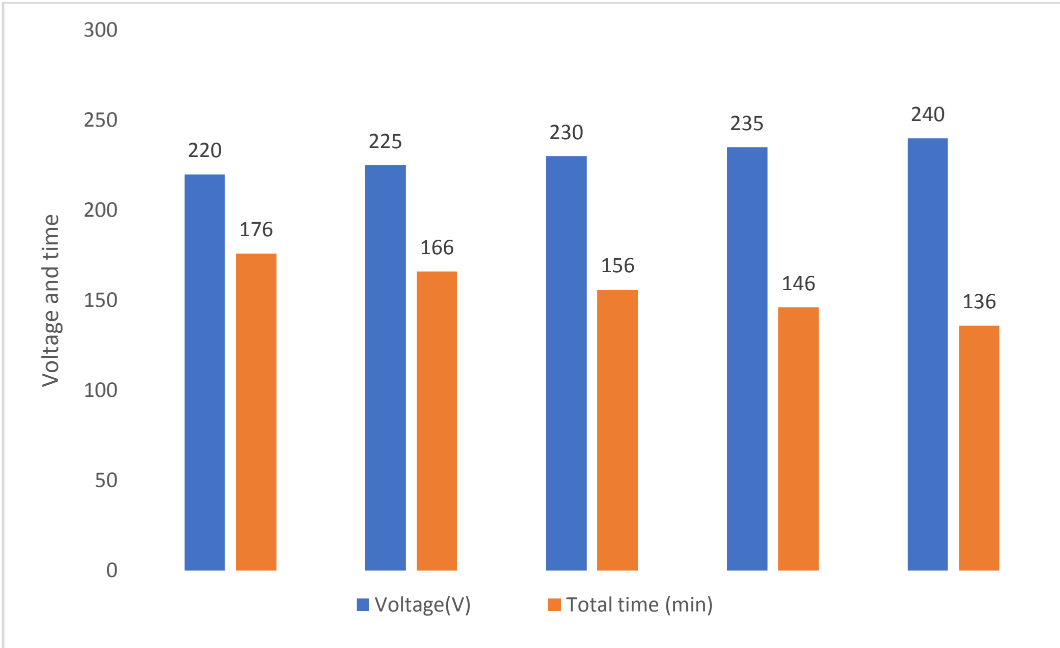
Fig.6. Temperature of 96˚C at voltage gradient of 17.14 V/cm for 136 min.

Source, Aaradhana Patel. 2018. Investigation on Application of Ohmic Heating for Parboiling of Paddy. Unpublished thesis, COAE, JNKVV, Jabalpur.

Fig. Regression curve between timeand temperatureat 15.71, 16.07, 16.43, 16.79 and 17.14 V/cm.

3.3. Time taken in parboiling to reach the temperature of 96˚C at different voltages of 220, 225, 230, 235 and 240V

Temperature profiles indicate that with the increase in voltage from 220 V to 240 V, the parboiling time of samples was reduced 176 min to 136 min with respect to voltage. This result is the same asthat found by Zhong and Lima (2003). It is quite obvious from the Fig. 7that the parboiling rate increased considerably as the voltage wasIncreased.

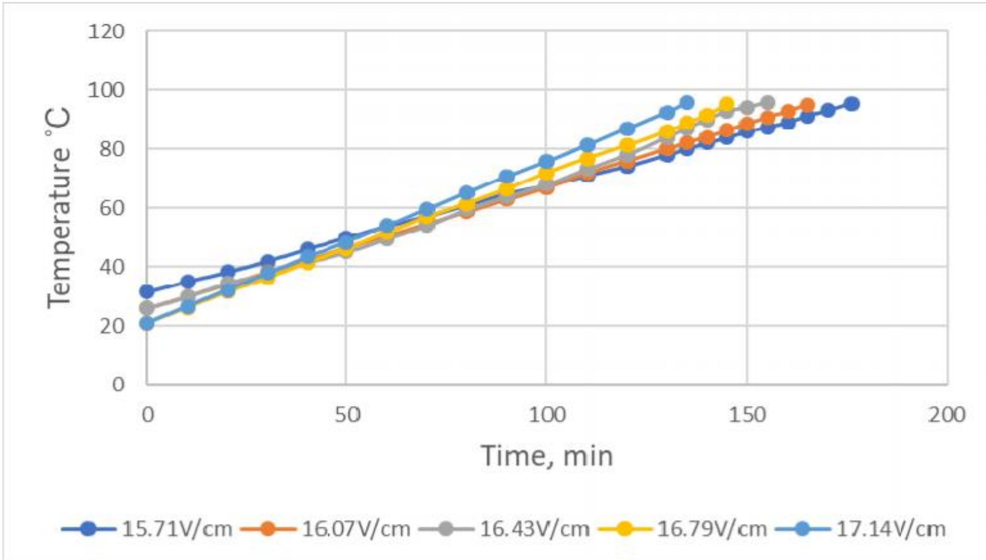


Source, Aaradhana Patel. 2018. Investigation on Application of Ohmic Heating for Parboiling of Paddy. Unpublished thesis, COAE, JNKVV, Jabalpur.

Fig. 7. Relationship between total time at 220, 225, 230, 235 and 240V

3.4. Time taken in parboiling to reach the temperature of 96˚C at voltage gradients of 15.71, 16.07, 16.43, 16.79 and 17.14 V/cm

Fig. 8. showsthat the heating rate increased considerably as the voltage was Increased. Time and temperature profiles indicated that with the increase in voltage gradient, temperature was increased, and the parboiling time of samples was reduced meaning thereby that the slope of curve for higher voltage was steeper than the slope of curve for lower voltage. At higher voltage, the current passing through the sample also increased, and this induced the faster heat generation.



Source, Aaradhana Patel. 2018. Investigation on Application of Ohmic Heating for Parboiling of Paddy. Unpublished thesis, COAE, JNKVV, Jabalpur.

Fig. 8. Relationship between time and temperature at 15.71, 16.07, 16.43, 16.79and 17.14 V/cm

4. CONCLUSION

Temperature profiles indicated that with the increase in voltage gradient from 15.71 V /cm to 17.14 V/cm, the parboiling time of samples was reduced 176 min to 136 min with respect to voltage. The parboiling rate increased considerably as the voltage gradient was Increased. Heating rate increased considerably as the voltage was Increased. Time and temperature profiles indicated that with the increase in voltage gradient, temperature was increased, and the parboiling time of samples was reduced meaning thereby that the slope of curve for higher voltage was steeper than the slope of curve for lower voltage. By ohmic heating parboiling method, soaking time was reduced and no need of boiler to generate steam in the steaming process. Soaking and steaming both process was completed in the ohmic heating chamber for parboiling of paddy. From the linear regression equations, it is evident that slope of curve was increased (0.3636 -0.5493) with increasing the voltage gradient 15.71 V /cm to 17.14 V/cm. It was observed, increasing the voltage gradient reduces the parboiling time, which implies the designing of parboiling tank should be rectangular cross-section having electrodes fitted on broader face will result a fast heating rate with high voltage gradient as compared to that for a parboiling tank with square cross section.

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