Original Research Article

Time - Temperature Combination of Ohmic Heating System for Parboiling of Paddy

ABSTRACT

The present study aimsed to atevaluateing the Time - Temperature combination of Ohmic Heating System for Parboiling of Paddy. Parboiling of paddy is carried out in three steps, i.e. soaking, steaming and 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 a 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 respect to voltage were studied by recording the temperature and time at voltage gradients15.71, 16.07, 16.43, 16.79 and 17.14 V/cm during the ohmic heating process. The parboiling rate increased considerably as the voltage gradient was Increased. The heating rate increased considerably as the voltage was Increased. 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 processes was completed in the ohmic heating chamber for parboiling of paddy. Typical temperature profiles at five different voltage gradients15.71, 16.07, 16.43, 16.79 and 17.14 V/cm up temperature of 96°C for paddy and water mixture of 1:3, (500 g paddy and 1500 ml water) was used for one experiment in the ohmic heating cylinder chamber. Time and temperature profiles indicated that with the increase in voltage gradient, the temperature was increased, and the parboiling time of samples was reduced meaning thereby that the slope of the curve for higher voltage was steeper than the slope of the 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 is a 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, kernels awere

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 electrically conductive food material obeys Ohm's law and heat is generated due to the electrical resistance of food.

$$V \propto I$$

V = IR eq.1

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

Comment [WU1]: Use equation editor for all equations

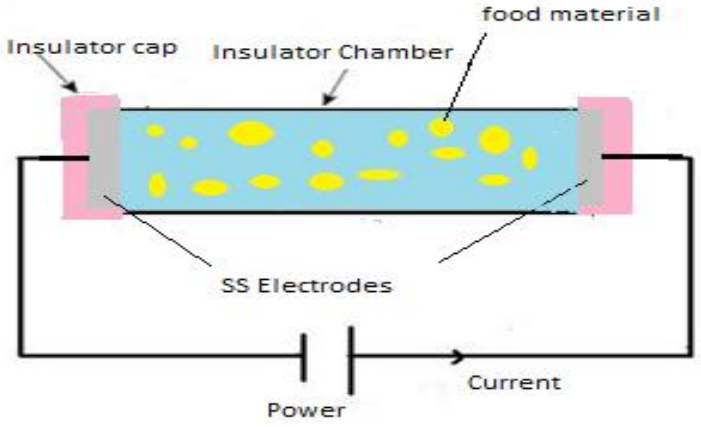


Plate.1 Principle of ohmic heating

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 a boiler, fuel tank, water tank, economizer, air preheater, mounting accessory, 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]. The present study aims to evaluate the Time - Temperature combination of Ohmic Heating System for Parboiling of Paddy. Therefore, in this study, an experimental set-up of ohmic heating was developed for parboiling of paddy.

2. MATERIAL AND METHODS

This section deals with the description of theoretical consideration, engineering principle, 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 an 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 the container is removable when the 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.

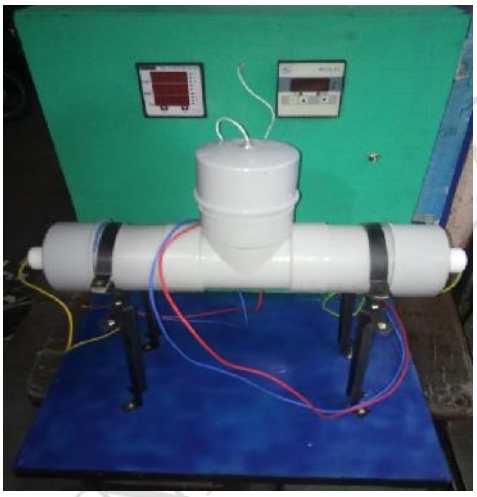


Plate 2.a Experimental set-up

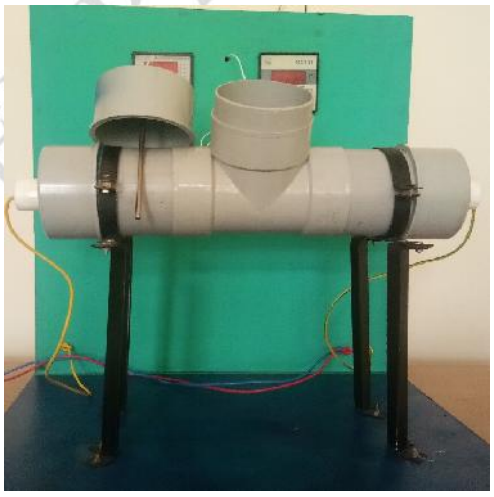


Plate 2.b Temperature sensor with cap

2.1. Selection of variables

Input voltage gradients15.71, 16.07, 16.43, 16.79 and 17.14 V/cm and the temperature of 96^{0}C were taken as independent variables, whereas 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 varieties which is grown in the 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].

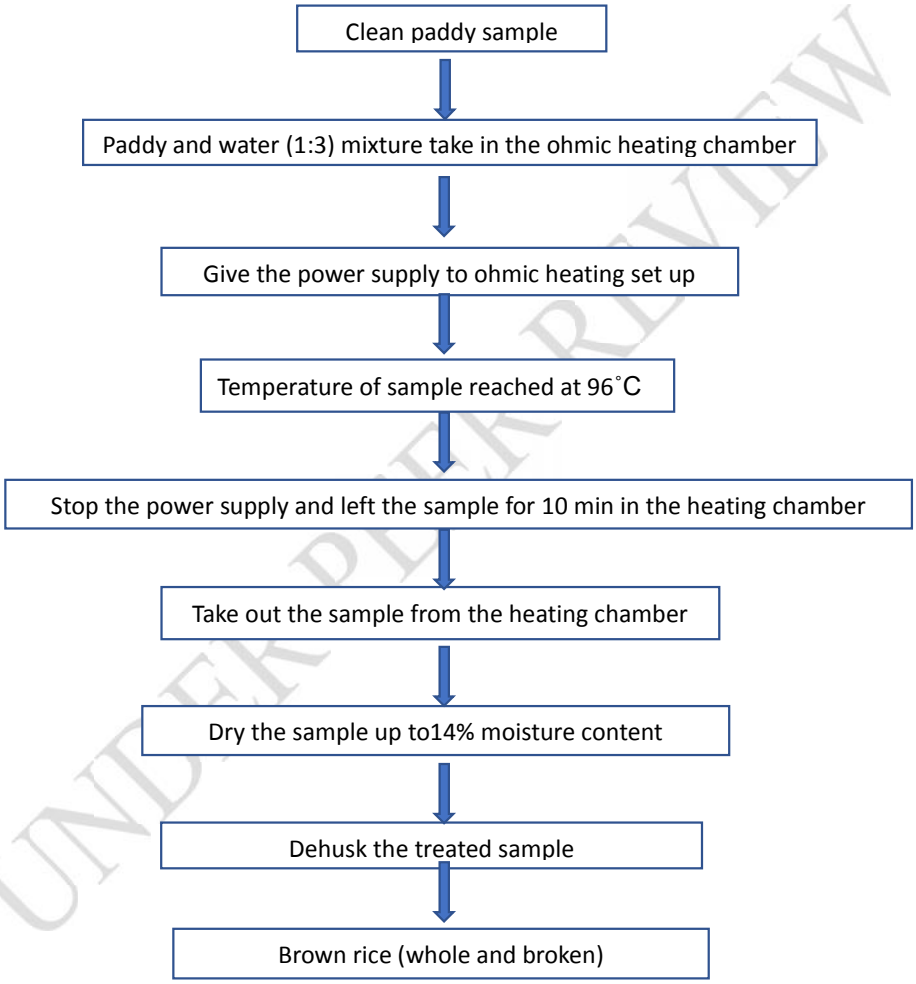


Fig 1. Process flow for paddy processing; parboiling, drying and milling

2.3. Process of parboiling

During the parboiling process, 10 samples were selected for the process and each sample was fed into the 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). The 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 the 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 important technology for the research purpose, professionalism and widely used for food processing industries because of its advantages over conventional heating technology. Researchers and food processing industries found superior quality product with minimal nutritional or quality degradation after using the ohmic heating technology. Its allow uniform and fast heating, simple process and designing ohmic 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 respect to voltage were studied by recording the temperature and time at voltage gradients of 15.71, 16.07, 16.43, 16.79 and 17.14 V/cm during the ohmic heating process. Typical temperature profiles at five different voltage gradients of 15.71, 16.07, 16.43, 16.79 and 17.14 V/cm up temperature 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 the form of the 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. The relationship between time and temperature at voltage gradient of 15.71V/cm,

The fig. 2, 3, 4, 5 and 6show the relationship between the time taken to reach the temperature of 96˚C for parboiling of paddy and a a 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 attaining the temperature of 96˚C for parboiling of paddy was 176, 166, 156, 146 and

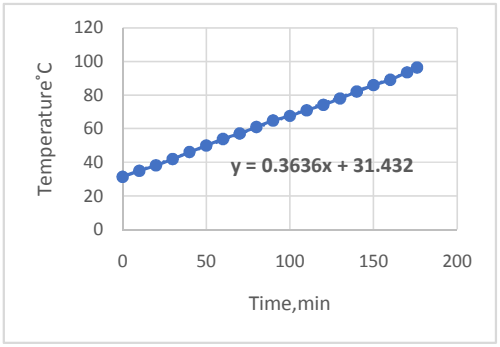


Fig.2. Temperature of 96˚C at voltage gradient of 15.71V/cm for 176 min.

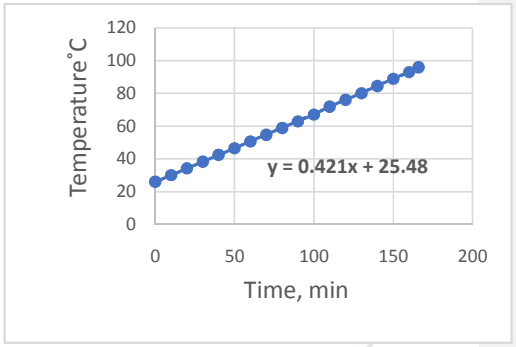


Fig.3. Temperature of 96˚C at voltage gradient of 16.07 V/cmfor 166 min.

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

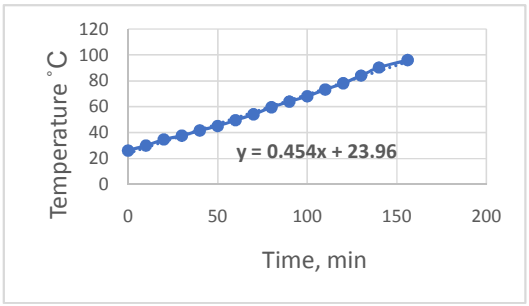


Fig.4. Temperature of 96˚C at voltage gradient of 16.43 V/cm for 156 min.

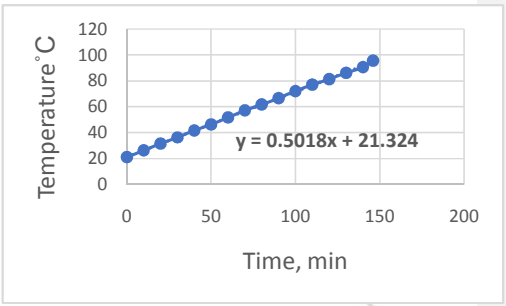


Fig.5. Temperature of 96˚C at voltage gradient of 16.79 V/cm for 146 min.

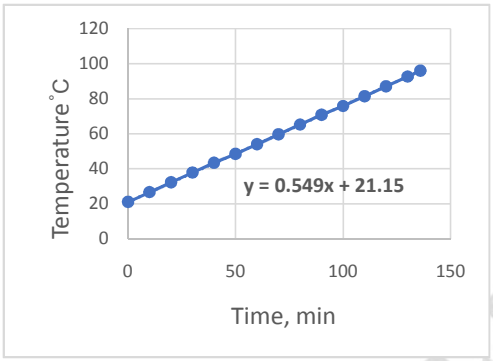


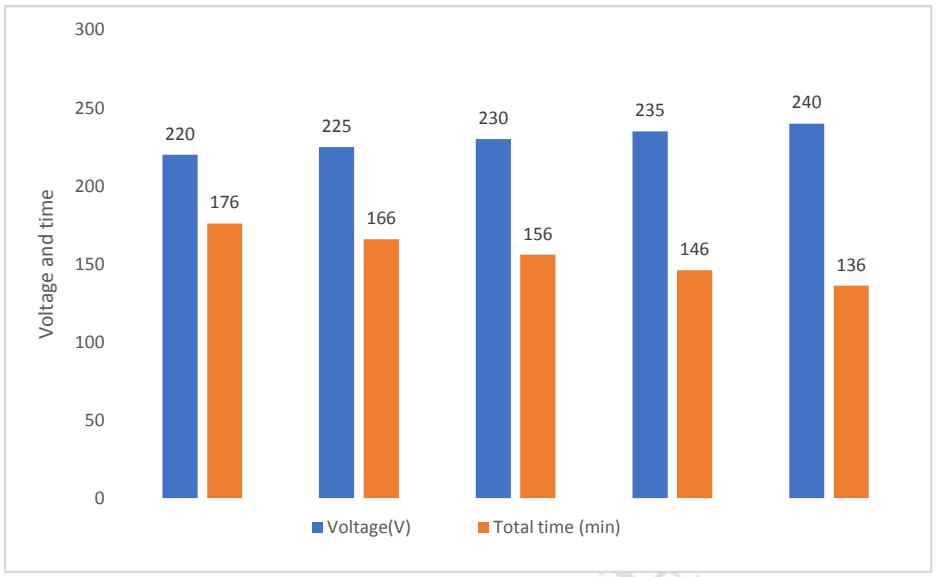
Fig.6. Temperature of 96˚C at voltage gradient of 17.14 V/cm for 136 min.

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

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

3.3. Time is 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 as that found by Zhong and Lima (2003). It is quite obvious from Fig. 7that the parboiling rate increased considerably as the voltage wasIncreased.

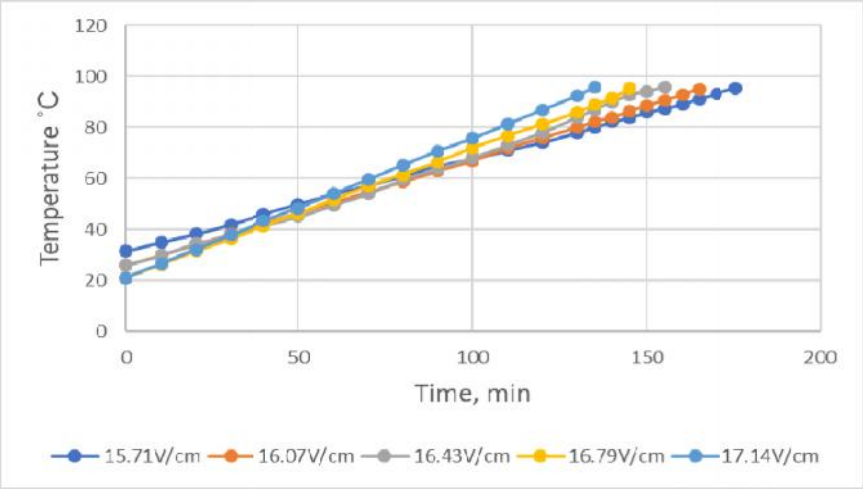


Source, Aaradhana Patel. 2018. Investigation on Application of Ohmic Heating for Parboiling of Paddy. Unpublished thesis, COAE, JNKVV, Jabalpur.

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

3.4. Time is 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. shows that the heating rate increased considerably as the voltage was Increased. Time and temperature profiles indicated that with the increase in voltage gradient, the temperature was increased, and the parboiling time of samples was reduced meaning thereby that the slope of the curve for higher voltage was steeper than the slope of the 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, the temperature was increased, and the parboiling time of samples was reduced meaning thereby that the slope of the 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 processes was completed in the ohmic heating chamber for parboiling of paddy. From the linear regression equations, it is evident that the 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 in a fast heating rate with high voltage gradient as compared to that for a parboiling tank with square cross-section.

REFERENCES

[1]Lbukun E O. 2008. Effect of prolonged parboiling duration on proximate composition of rice. Scientific Research and Essay. 3(7): 323-325.

[2] Mohanty S N, Bal S, Das S K and Panda M K J. 2002. Effects ofhydrostatic parboiling on milling quality of rice. J. Agril. Engng., 39(2): 9-14.

[3] Amitabh Anupam, Kashyap Vinita , Kumar Manish, Kumari Anuradha and Kumar Vishal. 2017. Effect of ohmic heating on processing of soymilk in comparison to conventional process. International journal of current microbiology and applied sciences. 6(12):2918-2926.

[4] Dhingra Devinder, Chopra Sangeeta and Rai D R. 2012. Stabilization of raw rice bran using ohmic heating. Agric res. 1(4):392–398.

[5] Ayamdoo J A, Demuyakor B, Dogbe W and Owusu R. 2013. Parboiling of paddy rice, The Science and perceptions of it as practiced in northern Ghana. International journal of scientific & technology research. 2(4):13-18.

[6] Anonymous. 2015.https://www.scribd.com/doc/275701042/Projectprofile-Raw-Boiledrice.

[7] Ekpodile Blandine A and Honfoga Barthelemy G. 2015. Effects of industrial paddy processing on local rice competitiveness in Glazoue District, Benin Republic. british journal of economics, management & trade. 10(1): 1-13.

[8] Kautkar Sheshrao Sakharam, Pandey Jai Prakash, Singh Anupama, Kumar Anil and Shukla Anil Kumar. 2016. Development of ohmic heating apparatus for extraction of rapeseed oil. International Journal for Innovative Research in Science & Technology. 2(11):211-215.

[9] Kautkar Sheshrao, Pandey Ram Krishna, Richa Rishi and KothakotaAnjineyulu. 2015. Temperature dependent electrical conductivities of ginger paste during ohmic heating. International Journal of Agriculture, Environment and Biotechnology. 8(1):21-27.

[10] Kumar J P, M Ramanathan and T V Ranganathan. 2014. Ohmic heating technology in food processing – A review. International journal of engineering research and technology. 3:1236-1241.

[11] Miah M A K, Haque A, Douglass M P and Clarke B. 2002. Parboiling ofrice. Part

I: Effect of hot soaking time on quality of milled rice. International J. Food Sci. Technol., 37: 527-537.

[12] Sowbhagya C M and Ali S Z. 1990. Effects of presoaking on cooking timeand texture of raw and parboiled rice. J. Food Sci. Technol., 28(2): 76-80.

[13] Akhter Muhammad, Ali muhammad azhar, Haider zulqarnain and Muzammil Shahzad. 2014. Efficacy of parboiling on physico-chemical properties of some promising lines/varieties of rice (oryza satival.). Sci. Tech. and Dev. 33 (3): 115-122.

[14] Khalaf and Sastry. 1996. Effect of fluid viscosity on the ohmic heating rate of solid-liquid mixtures. J Food Eng. 27:145-58.

[15] Nagarajan N, Madesh A, Jaisabari K and Jaya Prakash N. 2016. fabrication of paddy drier processor global research and development. Journal for Engineering.1(3): 2455-5703.

[16]Aaradhana Patel. 2018. Investigation on Application of Ohmic Heating for Parboiling of Paddy. Unpublished thesis, COAE, JNKVV, Jabalpur (M.P.).