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Effect of Moisture content on some Electrical Properties of Rice Bran by using LCRQ Meter

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ABSTRACT: Electrical properties determination is used in a variety of disciplines and industries. This paper provides a quick overview about the use of electrical properties in agricultural materials like rice bran. Electrical properties like electrical resistance, capacitance and electrical conductivity of rice bran subjected to different moisture contents (9.4, 12, 15, 20, 25, 30 & 35% w.b.) for ohmic heating were determined through LCRQ meter. Experimental data was analyzed by one way ANOVA through MS-Excel. Results showed that capacitance and electrical conductivity were significantly ($P<0.05$) increased with increase in moisture contents (i.e., from 9.4 to 35%) where as the resistance significantly ($P<0.05$) decreased with increased moisture contents. Correlation equations for resistance, capacitance and electrical conductivity against moisture content with R^2 values of 0.983, 0.99 & 0.983 respectively were developed. The mean±standard deviation for capacitance and resistance were observed as 1.80±0.6 nF and 11.884±6.33 kΩ within the moisture range.

Keywords: Electrical properties, Capacitance, Resistance, Electrical Conductivity and LCRQ meter.

INTRODUCTION

It is important to generate fundamental engineering data using engineering properties such as electrical properties (Novak, 2011) for the design and development of any machinery. Electrical properties (capacitance, resistance, and electrical conductivity) are crucial in the agricultural and food processing industries, which rely primarily on electricity to heat their products (Monika *et al*., 2018). Electrical properties are used to study of moist materials and the development of measurement equipment, both is essential (Hlavacova, 2003).

In ohmic heating and cell membrane techniques, determining conductivity is extremely important (Priyathkova and Hlavacova, 2009). For electroporation of membranes, for example, ohmic technique is used, during which the membrane's resistance returns to values in the GΩ (Hlavacova, 1999). Electrical conductivity or resistivity measurements can be used to investigate cell membrane properties at the microscopic level.

For ohmic heating, it's critical to understand the impact of moisture content on rice bran electrical characteristics. During ohmic heating, an electric field is passed through rice bran, which is mostly dependent on the resistance given by the rice bran (Dhingra *et al*., 2012). With the assistance of physics, the electrical properties measured by the LCRQ metre were made quick and accurate (Monika *et al*., 2018). In the development of ohmic heating devices, electrical conductivity is a significant parameter (Dhingra and Chopra, 2014).

Monika *et al*., (2018) explored the study on variation of physiochemical and electrical properties with the ambient storage conditions at different stages of maturity. Mango sampling based on randomized block design was adopted. Parameters like size, sphericity, total soluble solid (TSS), titrable acidity (TA), colour and electrical properties were studied. Results showed that L, a, b color values, pH, and TSS values were found to be increasing with the storage period, while size and TA of fruit decreased. The increase in organoleptic rating was found to be associated with change in fruit color, TSS, acidity and fruit size.

Dhingra and Chopra (2014) studied the electrical characteristics of full fat raw rice bran. Results found that the average values of capacitance and resistance of rice bran having a moisture content of 30 % (w.b.) was observed to be 2.32 nF and 9.01 kΩ respectively. The specific resistance of rice bran was 94.3 Ωm.

Dhingra *et al.*, (2012) studied the electrical conductivity (EC) values for ohmic heating of rice bran by 10 kg/batch ohmic system at different moisture contents (20, 30, and 40%, w.b.) by applying voltage gradients between 44 and 72 V/cm. They were observed that the EC increased with increase in temperature and moisture content. EC values for rice bran at 20, 30 and 40% moisture content were in the range of 0.01–0.06, 0.04–0.14 and 0.08–0.23 S/m, respectively.

Kardjilova *et al.*, (2012) measured the electrical properties i.e., Resistance R, impedance Z, capacity C, relative permittivity of rapeseed seeds with different moisture content with LCR meter. Results showed that the electrical properties of rapeseed seeds functionally dependent on the frequency. R values increases with decreased moisture contents and C values increases with increased moisture contents.

The traditional approach of determining electrical properties with an electrical conductivity metre is time consuming and cumbersome, however the LCRQ metre eliminates these issues (Kardjilova *et al.*, 2012) and also present work aims at to study electrical properties of rice bran for further development of ohmic system for stabilization of rice bran.

MATERIALS AND METHODS

Rice bran is a by product of rice milling that is finely granulated, light tan in colour, powdery in consistency, and has a bland odour. Freshly milled rice (*Oryza sativa* L.) of MTU-2716 variety bran was purchased from local rice mill and which was promptly sieved through a 20µm screen to remove broken rice, husks, and other extraneous elements. Sieved bran was adjusted to different moisture contents viz., 12, 15, 20, 25, 30, and 35% (w.b.). Rice bran with the required moisture content was made by spraying a precise amount of distilled water onto sieved rice bran and mixing well by hand.

Measurement of Capacitance & Resistance of Rice Bran

Electrical properties like capacitance (C) and resistance (R) of rice bran at different moisture contents were determined by using the LCRQ meter (Model: LCR 8C; M/S SS lab equipments, Hyderabad, India) with experimental set up. This procedure is easy and precise. For the measurement, a frequency of 100 Hz was chosen.

Developed an experimental set up in laboratory workshop which consists of a rectangular test cell made of acrylic sheets having dimensions 150×40 mm. Sample thickness was 30 mm. Two sides of the test cell were fitted with two electrode plates. The experimental setup electrode plates are connected with the capacitor and resistor pins in parallel and the rice bran sample placed between the electrodes with capacitor and resistor at various moisture contents. Note down the readings of C and R values in triplicate.

The experimental setup electrode plates are connected with the capacitor and resistor pins in parallel and the rice bran sample placed between the electrodes with capacitor and resistor at various moisture contents. Note down the readings of C and R values in triplicate. The experimental data were analyzed for ANOVA by MS Excel, 2020 to know the significance between the moisture content and different electrical properties (Capacitance, Resistance and electrical conductivity) of rice bran.

Determination of electrical conductivity of rice bran. Electrical conductivity of product is has a very crucial role in ohmic heating. The electrical conductivity is material's ability of flow of electric current through it. Electrical conductivity of the rice bran samples was calculated using the following equation from the above measured resistance values.

Electrical Conductivity (S/m) of rice bran was calculated using the following equation (1).

$$\sigma = \frac{LI}{AV} = \frac{L}{AR} \qquad (1)$$

(Since R = V/I)

Where, σ = Electrical conductivity of the sample (Sm^{-1})

L = Space between electrodes (m)

A = Heating surface area of the electrodes (m^2)

I = Electrical current passing through the sample (A)

V = Voltage applied between electrodes (V)

RESULT AND DISCUSSION

Effect of moisture content on capacitance and resistance. The resistance (R) values significantly (P<0.05) decreases from 21.23 to 4.88 KΩ with increasing moisture content from 9.4 to 35 % (w.b.). From the Fig. 1, higher R values observed in low moisture content samples and low R values observed in high moisture content samples. The results are in good agreement with Kardjilova *et al*., 2012. Capacitance (C) of rice bran samples is high (2.67 nF) at higher moisture content (35% w.b.) and low (1.01 nF) at lower moisture content i.e., 9.4% w.b. It can be found that, a significant increase (P<0.05) of capacitance was observed with increase in moisture content.

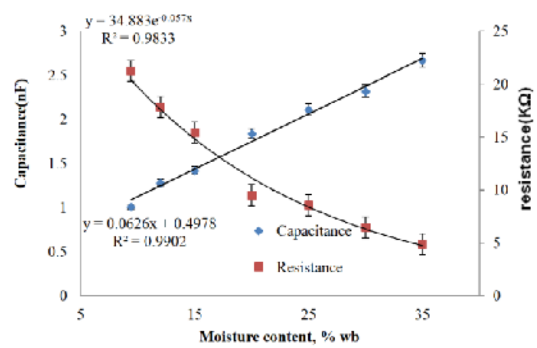

Fig. 1. Effect of moisture content on Capacitance and Resistance of rice bran.

Resistance values are inversely proportional to the capacitance. The results obtained in the present study are in best conformity with Dhingra and Chopra, (2014). ANOVA for resistance and capacitance were tabulated in Table 1 & 2. The output shows that high F values and $P<0.05$. It can be concluded that a significance effect on resistance and capacitance of rice bran with different moisture contents.

The moisture content is place a very crucial role in the measurement of electrical properties. A small change in moisture content vigorously changes the electrical properties. These findings are in good concurrence with the conclusions of Priatkova and Hlavacova (2009). The sharp decline of electrical resistance of rice bran during the early processing time, and following moderate decrease, can be attributed to the increasing of ions concentration in the electrolyte of the fruit leads to the decreasing of resistance. The findings are in better association with the results obtained from Jha and Matsuoka, (2000).

Table 1: ANOVA for electrical resistance (R) on moisture content (MC).

Source of Variation	SS	Df	MS	F	P-value	F crit
Between MC & R	279.4645	1	279.4645	30.31944	0.00598	4.747225
Within Groups	776.3913	12	64.69927			
Total	1055.856	13				

Table 2: ANOVA for electrical capacitance (C) on moisture content (MC).

Source of Variation	SS	Df	MS	F	P-value	F crit
Between MC & C	1277.733	1	1277.733	27.99646	0.000191	4.747225
Within Groups	547.669	12	45.63908			
Total	1825.402	13				

The best form of exponential equation (equation 2) was fitted to the data of electrical resistance (R) and moisture content (M_c) with correlation coefficient of 0.983 and linear correlation equation (equation 3) was established with $R^2=0.99$ between capacitance (C) and (M_c). The equations are given below.

$$R = 34.88\, e^{(-0.05Mc)} \qquad (2)$$

$$C = 0.062M_c+0.497 \qquad (3)$$

Where,

R= Resistance, KΩ

C = Capacitance, nF

M_c = Moisture content, %w.b.

The mean ± standard deviation values of capacitance and resistance of rice bran within a range of 9.4-35% were observed as 1.80±0.6 nF and 11.884±6.33 kΩ respectively. The flow of current in ohmic chamber was largely controlled by the resistance offered by the hydrated rice bran. The observations were in good association with the results of Massah and Hajiheydari, (2000) as heating takes place, the electrical conductivity increases, indicating that the resistance offered by the bran layer will reduce and the current through the system will increase. The results are in good agreement with the findings of Dhingra and Chopra (2014).

Effect of moisture content on electrical conductivity (EC). From the Fig. 2, it can be observed that electrical conductivity values were significantly ($P<0.05$) increased from 0.0045 to 0.01957 S/m with increasing moisture content i.e., 9.4-35% (w.b.). EC was high in higher moisture content of rice bran and EC values in the range of 0.0045–0.0061 S/m were observed between 9.4-15% (w.b.) moisture content. Whereas, EC values were observed to be 0.01–0.01957 S/m for rice bran in the moisture range of 20–35 % (w.b.). The observations were in the measured range of findings of Jha and Matsuoka, (2000).

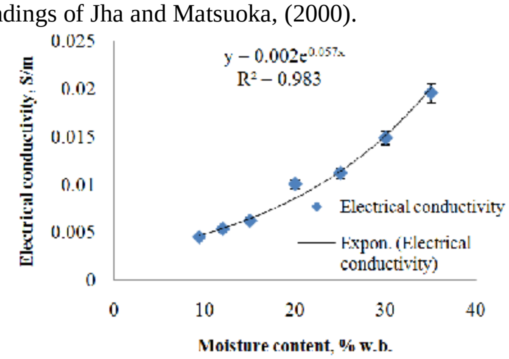

Fig. 2. Effect of moisture content on electrical conductivity of rice bran.

ANOVA for electrical conductivity on moisture content data was shown in Table 3. From that output (F value 33.64403 & $P<0.05$), it can be concluded that moisture content had a significant effect on electrical conductivity. The electrical conductivity is a critical parameter in the development of ohmic heating experiments. Ohmic heating is appropriate for EC values of samples in the range of 0.01 S/m - 10 S/m.

Table 3: ANOVA for electrical conductivity (EC) on moisture content (MC).

Source of Variation	SS	Df	MS	F	P-value	F crit
Between MC & EC	1529.426	1	1529.426	33.64403	0.0000847	4.747225
Within Groups	545.5088	12	45.45906			
Total	2074.935	13				

From the observed EC values of rice bran was less than 0.01 S/m at 9.4, 12 and 15 % moisture contents and nearly about 0.01005 at 20% (w.b.). The above said moisture contents were not suitable for ohmic heating. Hence, large voltages or very large amperes would be required to generate desired temperature by Joule effect as described by Knirsch *et al*., (2010).

Generally, EC increased with increase in moisture content. Moisture addition in rice bran has great importance to obtain an efficient ohmic heating and it results in proportional increase in higher ionic mobility and higher current flow (Yongsawatdigul *et al*., 1995). Developed and good fitted exponential equation was given in equation 4 for the EC values and moisture contents with $R^2 = 0.983$.

$$EC = 0.002e^{0.057}\ M_c \qquad (4)$$

Where,

EC= Electrical conductivity, S/m

M_c= Moisture content, %w.b.

CONCLUSION

— The electrical properties, capacitance (1.01-2.67 nF) and electrical conductivity (0.0045 to 0.01957 S/m) significantly ($P<0.05$) increases with increasing moisture content where as resistance (21.23 to 4.88 KΩ) values significantly ($P<0.05$) decreased with increased moisture content (9-35%).

— High R, lower C & EC values observed in low moisture content samples and low R, high C & EC values observed in high moisture content samples.

— Ohmic heating is appropriate for EC values of samples in the range of 0.01 S/m - 10 S/m. EC (0.0045 to 0.01957 S/m) significantly ($P<0.05$) increased with moisture content ranges 9.4 -35% (w.b.).

— Observed EC values of rice bran was less than 0.01 S/m at 9.4, 12 and 15 % moisture contents and nearly about 0.01005 at 20% (w.b.), the above moisture contents were not supposed for ohmic heating.

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Conflict of Interest. None.

REFERENCES

Dhingra, D. and Chopra, S. (2014). Ohmic heating system for stabilization of rice bran. *Agricultural Engineering Today*, *38*(2): 1- 6.

Dhingra, D., Chopra, S. and Rai. D. R. (2012). Stabilization of Raw Rice Bran using Ohmic Heating. *Agricultural Research*, *1*(4): 392-398.

Hlavacova, Z. (1999). Some electrical properties of amaranthus seeds. *Zemedelska Technika*, *45*(3): 99-104.

Hlavacova, Z. (2003). Low frequency electrical properties utilization in agricultural and food treatment. *Agricultural Research Engineering*, *49*(4): 125-136.

Jha, S. N. and Matsuoka, T. (2000). Non-destructive techniques for quality evaluation of intact fruits and vegetables. *Food Science and Technology Research*, *6*(4): 248-251.

Kardjilova, K., Bekov, E., Hlavacova, Z. and Kertezs, A. (2012). Measurement of Electrical Properties of Rapeseed Seeds with LCR Meter Good Will 8211. *International Journal of Applied Science and Technology*, *2*(8): 35-44.

Knirsch, M. C., Santos, A. S., Antonio, A. M., Vicente, O. S. and Penna, T. C. V. (2010). Ohmic heating: a review. *Trends Food Science Technology*, *21*(1): 436-441.

Massah, J. and Hajiheydari, F. (2000). Study of electrical resistance of apples. *Journal of Pomology*, *1*: 1031-1035.

Monika, K., Sangeeta, B. and Prameela, K. (2018). Assessment of Maturity of Mango (*Mangifera indices* L.) based on Electrical and Physiochemical Properties during Ambient Storage. *Journal of Agricultural Physics*, *18*(1): 107–113.

Novak, J. (2011). Electrical properties of colza seeds. *Acta Technologica Agriculture, 1:* 11-14.

Priatkova, L. and Hlavacova, Z. (2009). Uncertainties of the biological materials electrical properties measurement using the LCR bridge. *International student scientific conference*. RAAGMEWP, 251-256.

Yongsawatdigul, J., Park, J. W. and Kolbe, E. (1995). Electrical conductivity of pacific whiting surimi paste during ohmic heating. *Journal of Food Science*, *60*(5): 922–935.

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