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THERMAL PROPERTIES OF *ABELMOSCHUS ESCULENTUS*

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ABSTRACT

The estimations of specific heat, thermal conductivity and thermal diffusivity of *Abelmoschus esculentus* were resolved and their variety with moisture content (15-40% w.b.) and bulk density (578.7-750.5 Kg/m^3) explored. Thermal conductivity, thermal diffusivity and specific heat expanded with moisture content in the above moisture range. Thermal properties were discovered to be both moisture and bulk density subordinate. Bulk density of *Abelmoschus esculentus*s took after an illustrative association with moisture content. It was observed that thermal conductivity, thermal diffusivity and specific heat of *Abelmoschus esculentus* specimens were in the scope of 0.989 to 1.564 W/m.k, 11 x 10^{-8} to 6 x 10^{-8} m^2/s and 5 to 9 KJ/Kg.K, individual

Key words: Specific heat, Thermal conductivity, Thermal diffusivity, Moisture substance, Bulk density, *Abelmoschus esculentus* seed.

INTRODUCTION

Thermal technoquesare generally connected to sustenances to acquire amazing items. Consequently, thermal properties of farming material and nourishments needs to known to better comprehend their tendency and to have the capacity to create new innovations. Specific heat, thermal conductivity, thermal diffusivity and moisture diffusivity are among the essential properties. Specific heat is the property required in the estimation of the measure of vitality needed to change the temperature of an item, while thermal conductivity and thermal diffusivity are included in the determination of the rate of heat transfer exchange for productive procedure and supplies outline[1-6].

Harvesting *Abelmoschus esculentus* with high moisture content (about 40% w.b.) regularly brings about higher yields, less fledgling harm and less head dropping and

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shattering. Warm methodologies and capacity constitute two principal steps in *Abelmoschus esculentus* generation on the grounds that they impact the nature of both the seed and the oil. This moisture esteem changes somewhere around 10 and 12%, contingent upon the seed stockpiling period. For long stockpiling (more than a year), this worth ought to be something like 10% dry premise (d.b.), although for 6-mon stockpiling a greatest estimation of 12% d.b. is suitable[7].

Goals of this study were to focus the thermal conductivity, thermal diffusivity, and specific heat of *Abelmoschus esculentus*s over an extensive variety of moisture substance and bulk density, and to create comparisons for the forecast of these thermal properties as a capacity of moisture substance and bulk density.

EXPERIMENTAL

Materials and methods

Preparation of samples

Abelmoschus esculentus examples were reaped from the trial ranch in Ilam, Iran, and were put away in the fridge at temperature of 7 ± 4^{o}C until the tests were completed. The starting moisture substance of the horse feed specimens was controlled by utilizing standard stove strategy at 205 ± 4^{o}C. These tests were duplicated thrice to acquire a sensible normal. Normal moisture substance was discovered to be 41 ± 4% wet basis.

Thermal measurements

Thermal conductivity was dead set with a line source test, which was fabricate in our lab and which is like that portrayed by Jury et al.[8] and Bitra et al.[4] The thermal conductivity test was made with a hypodermic tubing 71 mm long and 1.5 mm distance across. Nickel chrome wire 0.05 mm in width with polyamide protection was used as the warmer wire. K sort thermocouple wires were utilized (0.05 mm distance across). The warmer wire and thermocouple wires were protected from one another and from the hypodermic tubing by polyamide. The round and hollow specimen holder was produced using acrylic with an outside width of 3 mm and a stature of 80 mm. Taking after this, the test was embedded through the inside of the specimen. The example holder was set in a water shower so as to heat transfer it to the sought temperature. At that point a current was connected and time-temperature information was recorded. Tests were completed at five moisture levels in the extents of 40 to 15% wet premise (40, 35, 30, 25, 20 and 15%). Tests at the coveted moisture level in the above extents were ready by molding them utilizing the system that was reported by Meghwal and Goswami[2].

The thermal conductivity of examples was dead set utilizing a line heat transfer source system, which is the most ordinarily utilized transient-state heat transfer exchange system. For an unendingly long line warmer in a boundless, homogeneous and isotropic test, the temperature at an outspread separation, r, from the line heat transfer source could be spoken to by the accompanying mathematical statement:

$$\frac{\partial T}{\partial t} = \alpha \left[\frac{\partial^2 T}{\partial r^2}\right] + \frac{1}{r}\frac{\partial T}{\partial r} \quad \ldots(1)$$

$$\alpha = \frac{k}{\rho CP} \quad \ldots(2)$$

Where, T is temperature at a distance r from the line-heat source probe (ºC), t is the time (s), k is thermal conductivity (W/m.K), α is thermal diffusivity (m^2/s), r is the distance from central axis probe (m), Cp is the specific heat (KJ/Kg. K), and ρ is the density (Kg/m^3). The solution to Eq. (2) is (5).

$$T - T_o = \frac{Q}{4\pi K}\left[\ln(t) + \ln\left(\frac{4\alpha}{r^2 e^{0.5772}}\right)\right] \quad \ldots(3)$$

Where Q is the heat input per unit length ($Q = I^2 \times R_s$), I is the current (A) and R_s is the electric resistance per unit length $\left(\frac{\Omega}{m}\right)$.

Eq. (3) shows a linear relationship between ($T-T_0$) and ln (t) with the slope S = Q/4πk. The thermal conductivity was calculated using Eq. (4).

$$k = \frac{Q}{4\pi s} \quad \ldots(4)$$

Thermal diffusivity, α, of the *Abelmoschus esculentus* samples can be estimated using –

$$\alpha = \frac{r_p^2 e^{0.5772}}{4t_o} \quad \ldots(5)$$

Where r_p is the radius of the thermal probe and t_0 is the intercept on the time axis of the $T-T_0$ versus ln (time) plot. Knowing α, k and ρ of the sample, its specific heat can be determined using the following relationship:

$$C_P = \frac{k}{\rho\alpha} \quad \ldots(6)$$

RESULTS AND DISCUSSION

Thermal conductivity

The thermal conductivity of *Abelmoschus esculentus* seeds (Fig. 1) was found to build from 0.079 to 0.134 W/m.k, as the moisture substance expanded (at temperature scope of 30 to 65ºC). The expanded thermal conductivity with expanding moisture substance may be because of higher warm conductivity of water contrasted with the dry material of specimen connected with air-filled pores. Comparable pattern was saw in the thermal conductivity of cumin seed[9], sheanut bit[10], borage seed[11], harsh rice[12], millet grains[13], Berberis fruit[5] and safflower[3].

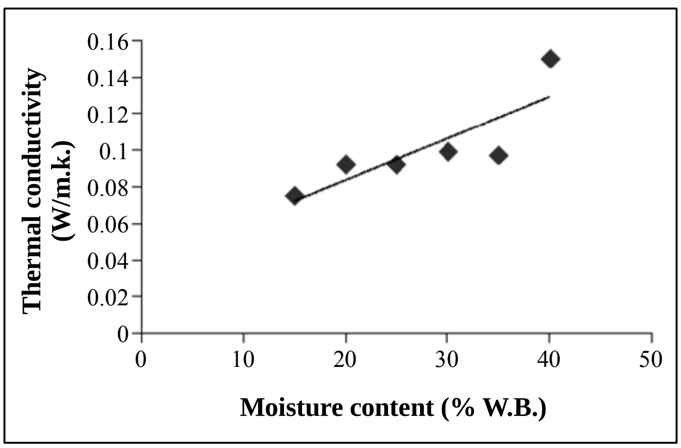

Fig. 1: Thermal conductivity of *Abelmoschus esculentus* as a function of moisture content

The relationship existing between thermal conductivity and *Abelmoschus esculentus* seeds moisture substance could be communicated utilizing the accompanying mathematical statements:

$$k = 0.56\ m + 0.789 \quad R^2 = 1.856 \quad \ldots(7)$$

The bulk density of the *Abelmoschus esculentus*s was saw to build from 570.1 ± 8 to 750.2 ± 9 Kg/m^3, as the moisture substance expanded from 15 to 40% wet premise (Fig. 2).

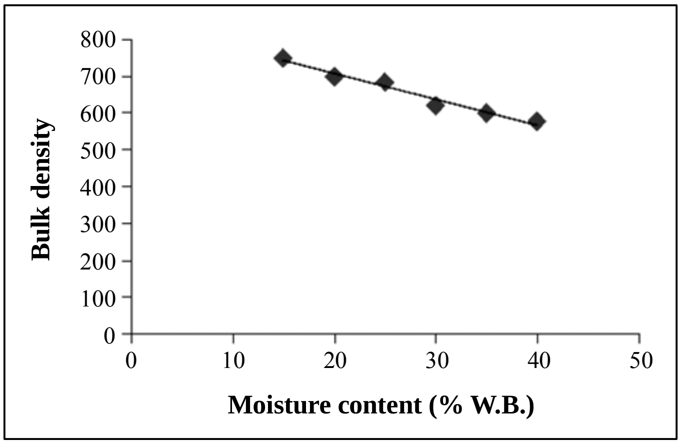

Fig. 2: Effect of moisture content on bulk density

This was because of the higher rate of increment in volume than weight. Comparative pattern was seen in the bulk density of *Abelmoschus esculentus* seed by Seifi and Alimardani[14], Gupta and Das[15], Isil and Izli[16] and Santalla[17]. It was observed that the thermal conductivity expanded with diminishing bulk density of the *Abelmoschus esculentus*s also comes about are demonstrated in Fig. 3.

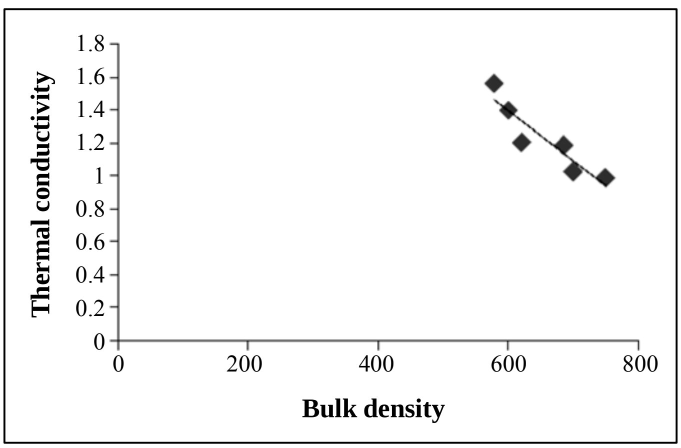

Fig. 3: Thermal conductivity of *Abelmoschus esculentus* as a function of bulk density

Such variety has been reported for the thermal conductivity of sheanut piece[10]. The accompanying relationship was got for the thermal conductivity of seed with bulk density:

$$k = 5 \times 10^{-5} \rho^2 - 0.0443 \rho + 9.2736 \quad R^2 = 1.975 \qquad \ldots(8)$$

Analyzings measured estimations of the moisture content and bulk density demonstrated that the impact of moisture substance on the thermal conductivity was higher than the impact of mass thickness. This may be because of the way that the warm conductivity of water reaches from 0.6106 to 0.6372 W/m.k[18], which is much higher than that of air filled in pores taking after diminishment in dam.

Thermal diffusivity

The change of thermal diffusivity of *Abelmoschus esculentus*s with moisture substance and bulk density, displayed in Figs. 4 and 5, demonstrates that it diminished from 10.5 x 10^{-8} to 7.5 x 10^{-8} m^2/s. It could be seen from Fig. 7 that the warm diffusivity diminishes

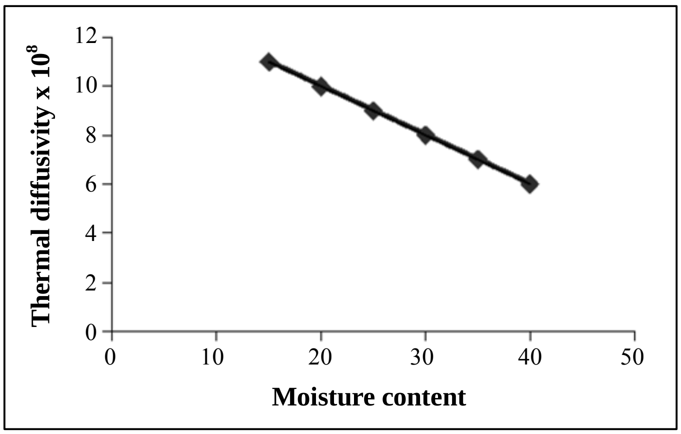

Fig. 4: Thermal diffusivity of *Abelmoschus esculentus* as a function of moisture content

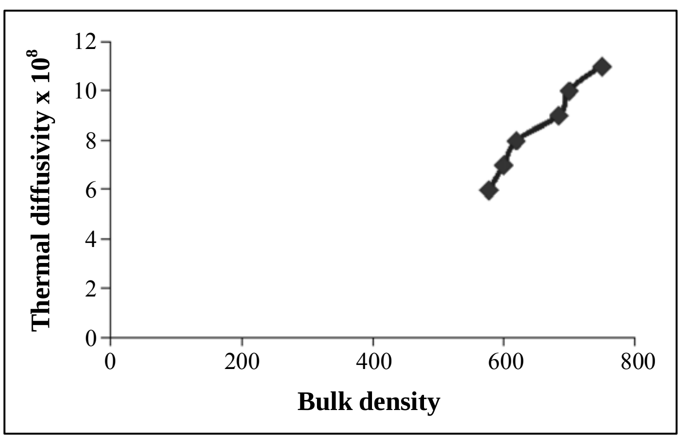

Fig. 5: Thermal diffusivity of black sunflower seeds as a function of bulk density

from 10.9 x 10^{-8} to 6.2 m^2/s with shifting moisture content between 15-35% then after it builds upto 7.710 x 10^{-8} m^2/s with differing moisture substance. The relationship between thermal diffusivity of *Abelmoschus esculentus* seeds, moisture content and bulk density is shown below:

$$\alpha\ (x\ 10^8) = 0.901\ M^2 - 8.807\ M + 12.980 \quad R^2 = 1.891 \quad \ldots(9)$$

$$\alpha\ (x\ 10^8) = 0.0501\ \rho^2 + 6.853\ \rho^2 - 108.235\ \rho + 2549 \quad R^2 = 1.998 \quad \ldots(10)$$

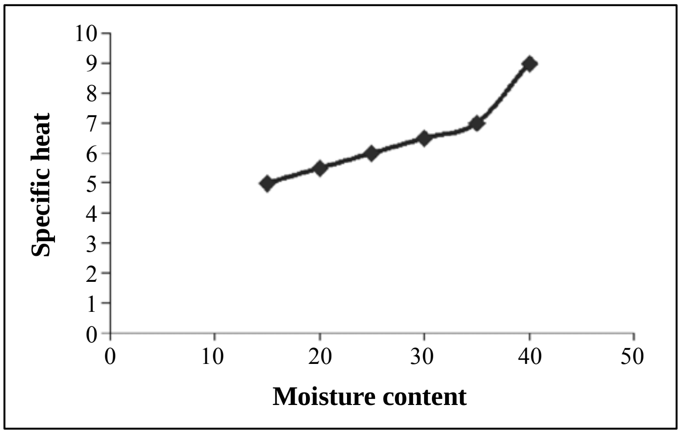

Fig. 6: Variation of specific heat with moisture content

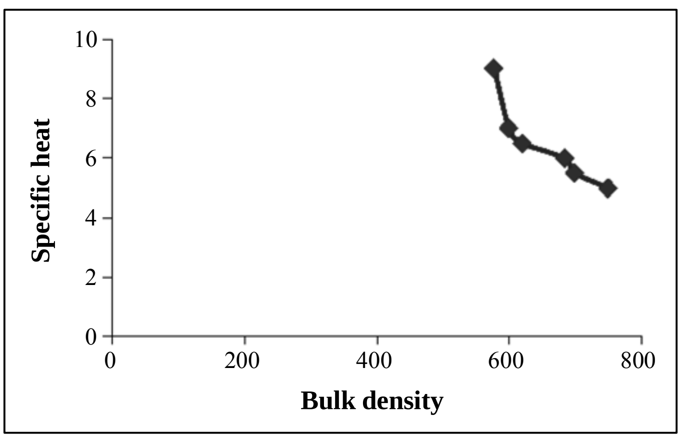

Fig. 7: Variation of specific heat with bulk density

A similar trend of thermal diffusivity for other seed materials were reported by many researchers such as for black pepper[2], guna seed[1], millet grains and flour[13] and banana[19]. The variety in specific heat with moisture content and bulk density of *Abelmoschus esculentus*s are displayed in Figs. 6 and 7. The qualities for a went from 2.55 to 8 KJ/Kg.K in the moisture substance and mass densities tried in this study. The estimation of specific heat was found to expand with diminish in bulk density. Likewise, a few analysts found the specific heat of some farming material to build with moisture content; Razavi and Taghizadeh[6] for pistachio nuts, Singh and Goswami[9] for cumin seed, Aviara and Haque[10] for sheanut bit and Deshpande et al.[20] for soybean. The relationship between the specific heat, moisture content and bulk density for *Abelmoschus esculentus* seeds can be expressed by the following regression equations:

$$C_P = -0.567\ M^3 + 0.963\ M^2 - 1.854\ M + 5.947 \quad R^2 = 1.089 \qquad \ldots(11)$$

$$C_P = -0.009\ \rho^3 - 0843\ \rho^2 + 98.84\ \rho - 2258 \quad R^2 = 1.698 \qquad \ldots(12)$$

Where Cp is the specific heat (KJ/Kg.K).

CONCLUSION

Thermal properties such as specific heat, thermal conductivity, and thermal diffusivity of *Abelmoschus esculentus* seeds were studied at varied moisture content using purpose-built instruments. The k, α and C_p values were in the range of 0.989 to 1.564 W/m.K, 11 x 10^{-8} to 6 x 10^{-8} m^2 /s, and 5 to 9 KJ/Kg.K, respectively, and increased with increasing moisture content. Bulk density of *Abelmoschus esculentus* seeds followed a parabolic relationship with moisture content.

REFERENCES

1. N. A. Aviara, M. A. Haque and L. A. O. Ogunjimi, Thermal Properties of Guna Seed, Int. Agrophys., **22**, 291-297 (2008).
2. M. Meghwal and T. K. Goswami, Thermal Properties of Black Pepper and its Volatile Oil, Int. J. Adv. Biotechnol. Res., **2(3)**, 334-344 (2011).
3. M. Kara, I. Ozturk, S. Bastaban and F. Kalkan, Thermal Conductivity of Safflower (Carthamus Tinctorius L.) Seeds, Spanish J. Agri. Res., **9(3)**, 687-692 (2011).
4. V. P. V. Bitra, S. Banu, P. Ramakrishna, G. Narender and A. R. Womac, Moisture Dependent Thermal Properties of Peanut Pods, Kernels and Shells, Biosys. Eng., **106**, 503-512 (2010).

5. M. Aghbashlo, M. H. Kianmehr and S. R. Hassan-Beygi, Specific Heat and Thermal Conductivity of Berberis Fruit (Berberis Vulgaris), J. Agri. Biolog. Sci., **3(1)**, 330-336 (2008).

6. S. M. A. Razavi and M. Taghizadeh, The Specific Heat of Pistachio Nuts as Affected by Moisture Content, Temperature and Variety, J. Food Eng., **79**, 158-167 (2005).

7. M. M. Bax, M. C. Gely and E. M. Santalla, Prediction of Crude Sunflower Oil Deterioration after Seed Drying and Storage Processes, JAOCS., **81(5)**, 511-515 (2004).

8. V. Jury, J. Y. Monteau, J. Comiti and A. Le-Bail, Determination and Prediction of Thermal Conductivity of arozen Part Baked Bread During Thawing and Baking, Food Res. Int., **40**, 874-882 (2007).

9. K. K. Singh and T. K. Goswami, Thermal Properties of Cumin Seed, J. Food Eng., **45**, 181-187 (2000).

10. N. A. Aviara and M. A. Haque, Moisture Dependence of Thermal Properties of Shea-nut Kernel, J. Food Eng., **47**, 109-113 (2001).

11. W. Yang, S. Sokhansanj, J. Tang and P. Winter, Determination of Thermal Conductivity, Specific Heat and Thermal Diffusivity of Borage Seeds, Biosys. Eng., **82(2)**, 169-176 (2002).

12. W. Yang, T. J. Siebenmorgen, T. P. H. Thielen and A. G. Cnossen, Effect of Glass Transition on Thermal Conductivity of Rough Rice, Biosys. Eng., **84(2)**, 193-200 (2003).

13. S. Subramanian and R. Viswanathan, Thermal Properties of Minor Millet Grains and Flours, Biosys Eng., **84(3)**, 289-296 (2003).

14. M. R. Seifi and R. Alimardani, Moisture-Dependent Physical Properties of Sunflower Seed (SHF8190). Mod. App. Sci., **4(7)**, 135-143 (2010).

15. R. K. Gupta and S. K. Das, Physical Properties of Sunflower Seeds, J. Agri. Eng. Res., **66**, 1-8 (1997).

16. E. Isil and N. Izil, Physical Properties of Sunflower Seed (Helianthus Annuus L.), Int. J. Agri. Res., **2(8)**, 677-686 (2007).

17. E. M. Santalla, Physical Properties of High Oleic Sunflower Seeds. Food Sci. Tech. Int., **9(6)**, 435-442 (2003).

18. N. N. Mohsenin, Thermal Properties of Food and Agricultural Materials, New York: Bordon and Breach (1980) pp. 1-196.

19. V. C. Mariani, A. G. B. de Lima and L. D. Coelho, Apparent Thermal Diffusivity Estimation of Banana During Drying using Inverse Method, J. Food Eng., **85**, 569-579 (2008).

20. S. D. Deshpande, S. Bal and T. P. Ojha, Physical Properties of Soybean, J. Agri. Eng. Res., **56**, 89-98 (1993).

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