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Hot Air Groundnut Drying

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ABSTRACT

In this research paper, the convective heat transfer coefficient for the groundnut drying by hot air given by an electrical dryer has been presented. The groundnut samples were dried up to the safe storage moisture content of 8 – 10% (wb). Wire mesh sieve of 15 × 25 cm^2 size was used to accommodate the single layer of groundnuts. The half hourly experimental data were used to evaluate the values of C and n in the Nusselt number equation by simple linear regression method and consequently convective heat transfer coefficient was determined. The value of convective heat transfer coefficient was observed to vary from 2.45 W/m^2 ^{o}C – 2.51 W/m^2 ^{o}C. The experimental error was observed to be 41.48%.

Keywords: Groundnut; Hot Air Drying; Convective Heat Transfer Coefficient.

I. INTRODUCTION

Groundnut (peanut) is the 'King of Oilseeds' because of its high nutritional values containing proteins, oil, carbohydrate, fat and calorific value [1]. It is grown in Kharif and Rabi seasons in India. India is the second largest groundnut producing country (5.5 million metric tons) followed by China (16.9 million metric tons) [2]. Drying of crop is the simple, cheap and most common traditional method of its preservation in which the moisture is removed to keep it safe from fungus infection [3]. After digging, groundnuts need to be dried earliest to its safe storage moisture level of 8 – 10%. In developing countries like India, poor farmers dry groundnuts under solar rays which takes about five days to dry it [4, 5]. Sun drying is of course cheapest method of drying, but it is followed by many limitations such as uncontrolled drying, ultraviolet radiations, rodents, animals, dust, dirt, birds and many more [6, 7]. Therefore, some means is required which not only gives constant drying but also reduces drying time.

The convective heat transfer coefficient is an important and critical parameter required for the suitable design of a dryer [8, 9]. It is associated by the temperature difference between groundnut surface and air, and the physical properties of the humid air which surrounds the groundnut surface**.** Akpinar [10] studied the drying of some agricultural products (Apple, strawberry, eggplant, garlic, mulberry, onion, pumpkin, and potato) under indoor forced convection drying (IFCD) mode and determined the convective heat transfer coefficients whose values were reported to lie from 0.64 W/m^2 ^{o}C to 7.12 W/m^2 ^{o}C. Kumar et al. [11] investigated the papad drying under open sun and IFCD modes and evaluated the value of convective heat transfer coefficients. The value of

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convective heat transfer coefficient was reported to be 3.54 W/m^2 ^{o}C and 1.56 W/m^2 ^{o}C under open sun drying and IFCD modes respectively. Anwar and Singh [12] carried out the studies of Indian gooseberry drying under IFCD mode to determine convective heat transfer coefficient which was found to lie within the range of 18.67 W/m^2 ^{o}C to 116.55 W/m^2 ^{o}C**.** Sahdev et al. [13] studied the drying of vermicelli under IFCD mode. The value of convective heat transfer coefficient was reported to vary from 0.98 W/m^2 ^{o}C to 1.10 W/m^2 ^{o}C. Sahdev et al. [14] investigated the drying of corn kernels under IFCD mode. The value of convective heat transfer coefficient was reported to vary from 1.02 W/m^2 ^{o}C to 1.04 W/m^2 ^{o}C. Kumar [15] proposed the drying of khoa under indoor forced convection drying condition and determined the convective and evaporative heat transfer coefficients. The values of the convective and evaporative heat transfer coefficients were found to lie in the range of 1.93 W/m^2 ^{o}C – 2.51 W/m^2 ^{o}C and 1.94 W/m^2 ^{o}C – 2.49 W/m^2 ^{o}C respectively. Recently Sahdev et al. [16] presented the groundnut drying under indoor forced convection drying mode and calculated the values of convective and evaporative heat transfer coefficients. The average value of convective heat transfer coefficient was observed to be 2.48 W/m^2 ^{o}C.

It is found from the literature that many agricultural products have been dried under indoor forced convection drying condition. The values of convective heat transfer coefficient for groundnut drying has been evaluated under hot air drying mode. This study has been carried out to confirm the results published by Sahdev et al. [16].

II. MATERIALS AND METHODS

2.1 Experimental set up and instrumentation

The groundnut samples (180g) for drying was kept in a rectangular wire mesh sieve of 15×25 cm^2 size. The sieve was kept over the digital weighing balance to measure the hourly moisture evaporation. The temperature of groundnut surface was measured with the help of thermocouples connected to a digital temperature indicator. The relative humidity (γ) and exit air temperature was measured by a digital hygrometer. The air velocity was measured by a digital anemometer. The schematic of the experimental setup is shown in Figure 1.

2.2 Sample preparation

Groundnuts purchased from farmers were soaked in water for twelve hours and then were kept in shed for one hour for its conditioning to remove extra moisture.

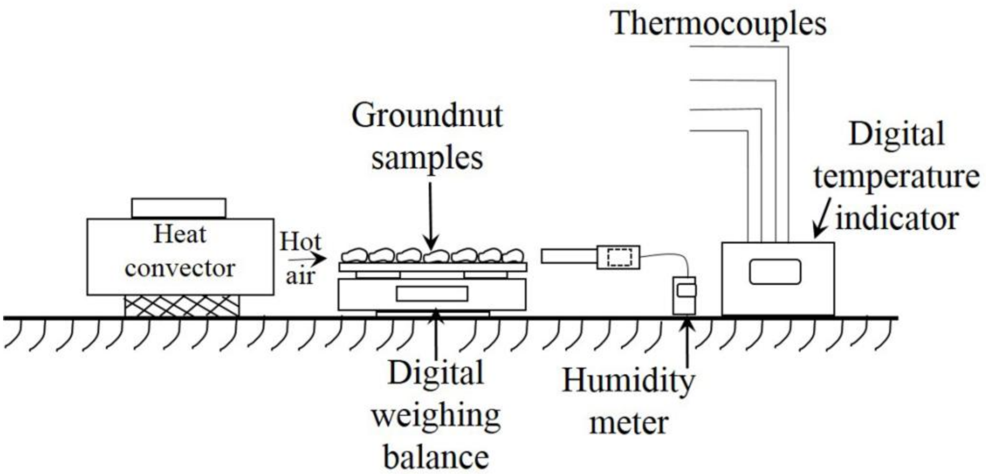

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Fig. 1. Experimental set up under hot air drying

2.3 Experimental Procedure

Groundnut samples in single layer were kept on wire mesh sieve of 15×25 cm^2 size directly over the digital weighing balance. The difference in weight between two consecutive time intervals (30 minutes) gave the moisture evaporation during the observed time interval. The data for the moisture removal, groundnut surface temperature, ambient temperatures, relative humidity, and exit air temperature were recorded. The experiments were stopped when the groundnuts attained safe storage moisture level of 8 – 10%.

2.4 Thermal modeling

The convective heat transfer coefficient (h_c) can be determined by the following procedure given by Sahdev et al. [16]:

$$Nu = \frac{h_c X}{K_v} = C(Re\,Pr)^n \tag{1}$$

or $$h_c = \frac{K_v}{X} C(Re\,Pr)^n \tag{2}$$

Where

Nu	Nusselt number
h_c	Convective heat transfer coefficient (W/m^2 ^oC)
X	Characteristics dimension (m)
K_v	Thermal conductivity of the humid air (W/m ^oC)
C	Experimental constant
Pr	Prandtl number
Re	Reynolds number
n	Experimental constant

2.5 Computation technique

The average of groundnut surface (T_g) and exit air (T_e) temperatures after the groundnut surface were determined at half an hour time interval for corresponding moisture evaporation. The physical properties of the humid air namely, thermal conductivity (K_v), dynamic viscosity (μ_v), density (ρ_v), specific heat (C_v) and partial vapor pressure $P(T)$ were evaluated for the mean temperature [$T_i = (T_g + T_e)/2$] given elsewhere [17]. These properties of the humid air and air velocity were used to calculate the Prandtl (Pr) and Reynolds (Re) numbers. The values of experimental constants C and n in equation (1) were determined by using linear regression technique analysis, and hence the value of convective heat transfer coefficient was evaluated.

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III. RESULTS AND DISCUSSION

The experimental data obtained for the drying of groundnut is given in Table 1. The data given in Table 1 were used to calculate the constants C and exponent n in the Nusselt number equation by simple linear regression method. Then the values of C and n were used in equation (2) to determine convective heat transfer coefficient. The evaluated values of convective heat transfer coefficients is given in Table 2.

Table 1. Experimental data for groundnut drying under hot air drying

	Sample 1					Sample 2				
Drying time (hrs)	Wt. (g)	T_g (° C)	T_e (° C)	m_{ev} $\times 10^{-3}$(kg)	γ (%)	Wt. (g)	T_g (° C)	T_e (° C)	m_{ev} $\times 10^{-3}$(kg)	γ (%)
0	180.0	-	-	-	-	180.0	-	-	-	-
0.5	155.5	30.6	26.88	24.5	0.3819	155.6	30.5	26.76	24.4	0.3878
1.0	142.9	45.4	35.78	12.6	0.2277	142.8	45.3	36.20	12.8	0.2388
1.5	134.7	46.6	35.91	8.2	0.1979	134.5	46.7	37.25	8.3	0.2088
2.0	129.2	47.3	36.51	5.5	0.1854	129.0	47.3	37.70	5.5	0.1965
2.5	126.2	47.6	37.22	3.0	0.1797	126.0	47.8	37.95	3.0	0.1880

Table 2. The values of convective heat transfer coefficients

Sample	C	n	h_c (W/m^2 °C)	$h_{c,\ avg}$ (W/m^2 °C)
1	0.98	0.31	2.45 – 2.49	2.48
2	0.98	0.31	2.48 – 2.51	2.50

The value of convective heat transfer coefficient was found to vary from 2.45 W/m^2 °C – 2.49 W/m^2 °C and 2.48 W/m^2 °C – 2.51 W/m^2 °C for drying of groundnut samples 1 and 2 respectively. The average values of convective heat transfer coefficients were observed to be 2.48 W/m^2 °C and 2.50 W/m^2 °C for drying of groundnut samples 1 and 2 respectively. The variation of convective heat transfer coefficient is shown in Figure 2. From Figure 2, it is observed that the value of convective heat transfer coefficient is almost constant throughout the experiments. The results are in accordance with the findings given by Sahdev [16], Akpinar [10], and Kumar [15].

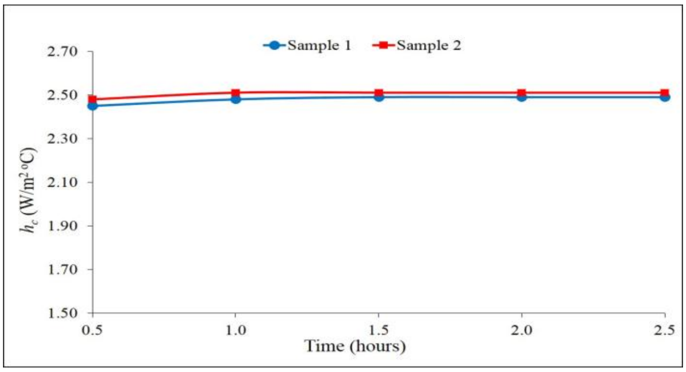

Fig. 2. Variation of convective heat transfer coefficient with respect to time

IV. CONCLUSION

The values of convective heat transfer coefficient for the drying of groundnut samples 1 and 2 under hot air drying (HAD) mode was found to vary from 2.45 W/m^2 ^{o}C – 2.49 W/m^2 ^{o}C and 2.48 W/m^2 ^{o}C – 2.51 W/m^2 ^{o}C respectively. The average value of convective heat transfer coefficient for the drying of groundnut samples 1 and 2 under HAD mode was found to be 2.48 W/m ^{2} ^{o}C and 2.50 W/m ^{2} ^{o}C respectively.

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