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Forced Convective Drying Of Potato Chips with Air Recirculation

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Abstract

Eatable containing high moisture has low shelf life as it gets colonies by micro bacteria. Our ancestors use to dry the fruits and vegetables so it can be preserved for a long time. The methods used by them are still used today but it have certain drawbacks like long drying periods. This experiment deal with forced convective drying of potato chips with air recirculation. Traditional practice involves slicing, boiling and salt bath of potato chips. This experiment includes tradition practice plus hoax that alum pretreated potato chips (β) dry faster than plain potato chips (α). 50 grams of potato chips having thickness about 1 mmbeen dried for 2 hours at velocity of 1 ms^{-1}, 1.5 ms^{-1} and 2 ms^{-1} with drying air temperature of 50°C, 60°C and 70°C and air recirculation ratio of 0%, 25%, 50% and 75%. Drying rate of potato chips was seem to be directly proportional to the drying air velocity and temperature but inversely proportional to air recirculation ratio. The drying rate of plain potato chips and alum pretreated potato chips seems to be identical and have standard deviation of 0.005162 % of w.b. per minute. The finest drying rate of0.5031 % of w.b. and 0.5016 % of w.b. per minute forplain potato chips (α)and alum pretreated potato chips(β)wasobtainat air velocity of 2 ms^{-1}, temperature 70°Cand 0% air recirculation.

Keywords:*Air recirculation, Forced convective drying, Potato chips*

1. Introduction

Numerous authors have studied the effect of air recirculation on the consumption and thermal efficiency of different dyers and products. Miller et al.[1] with respect to the dehydration of fruits studied the potential of air recycling in two orange packing line dryers. Drying potential was reduced by recycling part of the exhausted air by an average of 6.5% but recycling air reduced energy requirements by 29.6%. Rumsey, Thompson, and Young [2]reported energy savings of up to 30% by recirculating 60% of the air in the drying of walnuts. Thompson et al. [3]obtained energy savings of up to 15% and thermal efficiencies of 50% by recycling part of the exhausted air in a fruit tunnel dehydrator.

Young [4]found that the drying of peanuts using recirculated air supposed an average reduction of the energy requirements of 26% and an average increase in market values of 1.3%. The minimum consumption of a tunnel dehydrator of grapes was obtained for a percentage of recirculation of 92–99% for the different sections (Vanegas & Marinos- Kouris,[5]).

Walker [6]evaluated the effect of different percentages of air recirculation on the drying of segments of apple and peach obtaining savings of up to 46% and 53%, respectively. Liu [7]suggested rates of recirculation of 80% for the drying of apple ring and 70% for peach to obtain energy savings of approximately 50% and 46%, respectively. With respect to vegetable dehydration, Pelegrina, Elustondo, and Urbicain[8] simulated the drying of onion segments in a semicontinuous rotary dryer obtaining minimum energy consumption when the rate of recirculation was 84%. In these conditions the drying time increased by an average of 45%. In grain drying, Meiering, Daynard, Broewn, and Otten [9]registered energy savings of 24%. Giner and De Michelis [10]managed to increase thermal efficiency of maize dryers recirculating between 70% and 86% of the exhausted air. Prachayawarakorn et al. [11]obtained important energy savings for fluidized bed paddy drying recirculating up to 80% of the air without affecting the capacity of the dryer.

Vagenas and Marinos-Kouris [5]presented a mathematical model for the design and optimization of an industrial dryer for Sultana grapes and applied it to the determination of size and optimal operating condition of the dryer. Shukla and Patil [12]reviewed different dryers and drying technology for food crops developed in India and expresses due to complex process of dehydration, most of the developed dryers have certain limitation.

Singh [12]developed a small capacity dryer for vegetable and tested with cauliflower, cabbage and onion. The drying time was in the range 11-14 hour and overall energy efficiency was 28.21-30.83 % with 65°C temperature. Srivastav, Jain and Das[13] posted dehydration characteristics of green mango slices in re-circulatory tray dryer at a tray loading rate of 4-5 kg/m2, 60°C, 65°C, 70°C temperature and 30-96% air recirculation. The quality of dried product was found better than similar products available in market.

The present experiment variable was based on variables studied in research papers. Drying temperature ranges from 50°C to 70°C with air velocity of 1 ms^{-1}, 1.5 $ms^{-1}$and 2 ms^{-1} and air recirculation ratio of 0%, 25%, 50% and 75%.

2. Experimental Method

2.1 Experimental Setup and Procedure

Figure 1 shows the block diagram of setup. The air was supplied to the experimental setup via blower of 0.5 HP. The air then goes to 1 KW rod type (u bend) air heater which had spiral fins on it to ensure maximum heat transfer from heater to the air. Then the air goes to specially designed drying chamber which has eight identical drying chambers of 1 liters where temperature and velocity of forced drying air was maintained same.Plain potato chips (α) was kept in A,B,C and D drying chambers whereas alum pretreated potato chips (β) was kept in E, F, G and H drying chamber. This was done to ensure that if there are any variation occur in the condition of each drying chamber then the present arrangement of drying chamber will ensure that the same variation occur for both set of plain potato chips (α) and alum pretreated potato chips (β). The average of four samples was taken to ensure repeatability of experiment.

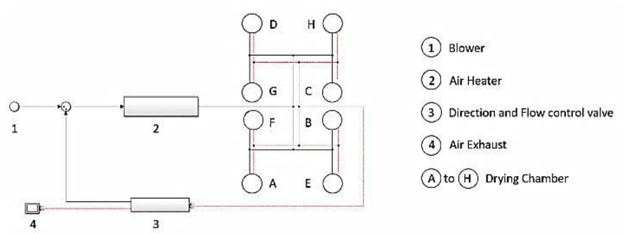


Figure 1 Block Diagram

Fresh potato chips about 1 mm were sliced and boiled in salt bath for 10 min to reduce the browning chemical effect. Then half of the chips of same batch was kept in normal drinking water and another half was kept in water which has alum dissolve in it for 1 hour. The ratio of alum powder dissolve in water was 1:1000.Photo 1 shows experimental setup. 50 grams of potato chips was kept in each drying chamber for experimentation. Weight of each same was taken after 15 min for next 2 hours. Photo 2 shows dried potato chips which was dried at 70°C drying air temperature (DAT) with 2 ms^{-1} drying air velocity (DAV) and 0 % air recirculation ratio (ARR).

Photo 1 Experimental Setup

Photo 2 Potato chips dried at 70℃ temperature, 2 ms^{-1} drying air velocity and 0 % air recirculation ratio

2.2 Data Reduction

Product moisture contain: Usuallypotato contain 80% of moisture contain on wet basis[14]. The weight of potato chips was converted into moisture contain by using equation 1. Initial weight (W_i) was subtracted from final weight (W_f) and divided by final weight (W_f) to get moisture contain on wet basis.

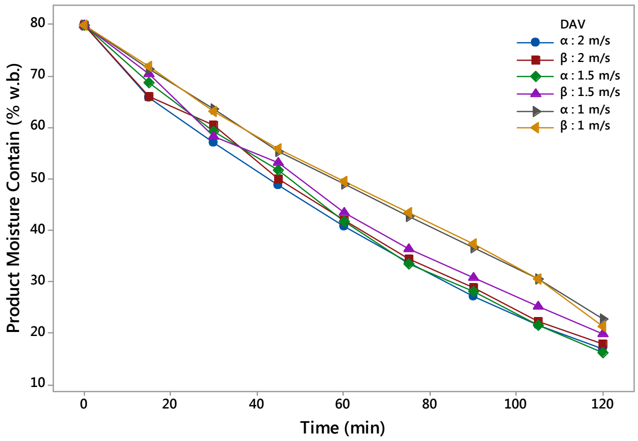
$$Product\ moisture\ contain\ (\%\ w.b.) = \left(100 - \left(\frac{W_i - W_f}{W_f}\right)\right) * 80 \quad (1)$$

Air recirculation ratio: Iguaz et al.[14]Used equation 2 to found out air recirculation ratio. Same equation was used in this experiment.

$$Air\ recirculation\ ratio\ (ARR) = \frac{Volumetric\ flow\ of\ recycle\ air\ stream}{The\ total\ flow\ impelled\ into\ the\ dryer} \quad (2)$$

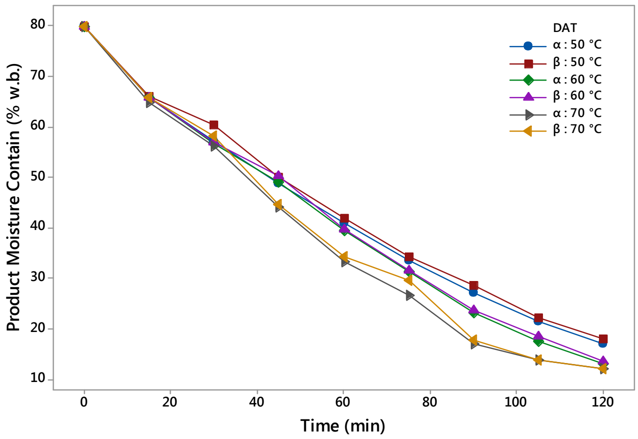
3. Results and Discussion

Graph 1 shows drying rate of α and β potato chips dried at 50°Cwith air recirculation ratio of 0% for different drying air velocity.Drying rate of α potato chips found to be 0.4697, 0.4664 and 0.4167%w.b. per minute for 2 ms^{-1}, 1.5 ms^{-1} and 1 $ms^{-1}$of drying air velocity. Drying rate of β potato chips found to be 0.4619, 0.4593 and 0.3892 %w.b. per minute for 2 ms^{-1}, 1.5 ms^{-1} and 1 ms^{-1} of drying air velocity respectively. Highest drying rate was found for drying air velocity of 2 ms^{-1}. Similar result was observed at 60°C and 70°C drying air velocity. α potato chips dried at rate of 0.4955 and 0.5031 %w.b. per minute for 60°C and 70°C respectively. β potato chips dried at rate of 0.4913 and 0.5016 %w.b. per minute for 60°C and 70°C respectively.2 ms^{-1}This clearly indicated that drying rate increses with increase in drying air velocity.



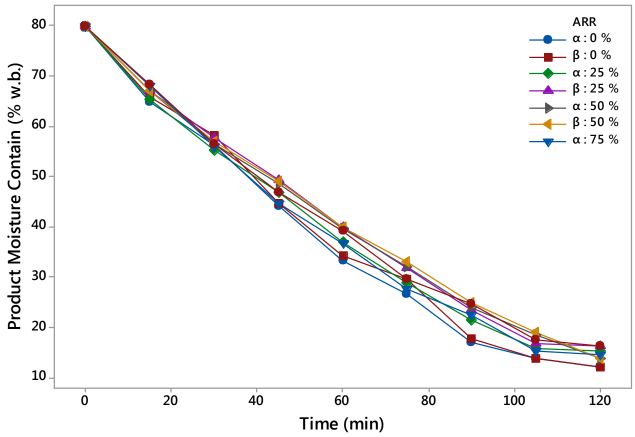
Graph 1 Product Moisture Contain (% w.b.) vs. Time (min) for different velocity at 50°C and ARR 0%

Graph 2 shows drying rate of α and β potato chips dried at drying air velocity of 2 ms^{-1}with air recirculation ratio of 0% for different drying air temperature.Drying rate of α potato chips found to be 0.4664, 0.4955 and 0.5031 %w.b. per minute for 50°C, 60°C and 70°C of drying air temperature. Drying rate of β potato chips found to be 0.4593, 0.4913 and 0.5016 %w.b. per minute for 50°C, 60°C and 70°C of drying air temperature. This indicates that higher drying air temperature leads to faster drying rate. In this experiment, 70°C drying air temperaturewith drying air velocity of 2 ms^{-1}harvest good drying rate result about 0.5031 and 0.5016 %w.b. per minute for α and β potato chips respectively.



Graph 2 Product Moisture Contain (% w.b.) vs. Time (min) for different temperature at 2 ms^{-1}and ARR 0%

Graph 3 shows drying rate of α and β potato chips dried at drying air velocity of 2 ms^{-1}and at drying air temperature of 70°C for different air recirculation ratio.Drying rate of α potato chips found to be 0.5031, 0.4894, 0.4785 and 0.484 %w.b. per minute for 0%, 25%, 50%, and 75% of air recirculation ratio. Drying rate of β potato chips found to be 0.5016, 0.4963, 0.4706 and 0.4711 %w.b. per minute for 0%, 25%, 50%, and 75% of air recirculation ratio. This indicates that higher air recirculation ratio result in lower drying rate. This is because outlet air relative humidity increases linearly at the beginning but as recirculation ratio increases, a point is reached from which outlet air relative humidity begins to increase exponentially. This describe the reason for greater retention times for higher recirculation ratio.[12][15] The best drying rate of 0.5031 and 0.5016 %w.b. per minute was achieved for70°C drying air temperature, 2 ms^{-1} of drying air velocity and 0% air recirculation ratio. The standard deviation among the drying rate of α and β potato chips was found0.005162 % of w.b. per minute.



Graph 3 Product Moisture Contain (% w.b.) vs. Time (min) for different Air Recirculation Ratio at 70°C and 2 ms^{-1}

4. Conclusions

In forced convective drying of potato chips, the rate of drying was directly proportional to the drying air velocity and drying air temperature but inversely proportional to air recirculation ratio. The reason could be that the dryingair relative humidity increases exponentially when exhaust air was mix with the fresh air and hence drying capacity of air decreases. Dehumidifying the exhaust air before mixing with fresh air is suggested so that air relative humidity will increase linearly and hence drying capacity will increases. The drying rate of plain potato chips and alum pretreated chips was identical and hence pretreating of potato chips with alum powder does not result in higher drying rate.

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