Effect of various process parameters on drying behavior of Potato-Review

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Abstract— Drying is an important technique to remove the moisture of the product. Various drying techniques are employed to dry different agricultural products. Each technique has its own advantage and limitation. So, choosing the right drying techniques is very important in the process of drying. The raw agricultural products with 80-90% moisture content are brought down to equilibrium moisture content for keeping in the short or long term storages. Present works involves the study of the effect of various process parameters on drying behavior of Potato. The study shows that temperature was the most effective parameter in drying rates. The effect of air velocity was more in low temperature.

Index Terms—Modeling, Potato drying, Rehydration ratio, Shrinkage percentage, drying rates, drying time, infrared radiation,

I. INTRODUCTION

Drying is one of the important operations in the industries like pharmaceutical, fine chemical and food industries. It is always beneficial to dry the product in less time and less area of drying. The drying of the product reduces its weight and thereby decreases transportation cost and also makes it more durable. Time required for drying and space required for drying are important factors in the operation.Potato drying was undertaken because it is a popular daily product and despite the availability of indigenous raw potatoes for snack production.Potato (Solanum tuberosum L.) is one of the unique and most potential crops having high productivity, supplementing major foodrequirement in the world. It is rich in carbohydrates, proteins, phosphorus, calcium, vitamin C, and β-carotene and has high protein calorie ratio.Amongst the world's important food crops, Potato is the fourthimportant food crop after wheat, rice and maize because of its' great yield potential and high nutritive value. The ratio of protein to carbohydrate is higher in potato than in many cereals and other tuber crops [1]. It constitutes nearly half of the world's annual output of all root and tuber crops and has always remained in the top ten since last twenty years. India ranks fourth in area with 14 lakh hectares and the third largest country in the world in production of potato after China and Russian federation with a production of 294.94 million tons and productivity of 17.86 tons per hectare.

Potato being a high moisture food is rich in enzyme namely peroxidases and cannot be sun-dried, as the traditional sun drying is a slow process and makes such food materials susceptible to fungal growth. It may also result in the loss of product quality from color degradation, microbial growth and poor rehydration etc. Thus the drying process must be undertaken in a closed dryer. [2]

II.REVIEW IF POTATO DRYING

Shahzadet al. [3]studied Performance Evaluation and Process Optimization of Potato Drying using Hot Air Oven. The effect of various process parameters on drying behavior of Potato (Solanum tuberosum) was studied, and the optimization of process parameters based on quality was investigated. Experiments were conducted to characterize the drying behavior of Potato cubes at various temperatures, potato cube sizes and blanching chemical treatments. The various drying models were evaluated for their suitability and Midilli's model was found to be best describing the drying characteristics of Potato cubes. A full second order model was developed for all the response variables, viz. Rehydration ratio, shrinkage percentage and mean sensory scores of overall acceptability and found to be significant at 1% level of significance. The effect of process variables was investigated at individual, linear, interactive and quadratic levels for each response. The data was optimized by 'Design Expert 7.0' for all the responses. Compromise optimum level of process variables for the responses were 80°C (1), 1cm cube size (-0.87) & KMS (0). The corresponding values of the responses were 4.584, 24.979 & 5.000 respectively.

Clementeet al [4] studied Influence of air velocities in dehydration of potato cubes.Air velocity is an important operating variable operation on hot air drying. For improving energy efficiency it is necessary to know its influence on the kinetics. The aim of this experiment was to establish the effect of air velocity on the drying kinetics of potato cubes. Potato cubes of 1 cm side were dehydrated at 60ºC and 0.5, 1.0, 1.5, 2.0, 3.0, 4.5, 7.0, 8.0 and 10.0 m/s. Experimental drying kinetics were modeled neglecting shrinkage and external resistance. It was observed that there is no interest to increase air velocity above 1.5 m/s, external resistance to mass transfer must be considered below this air velocity value.

Negaret al [5] studied EvaluationofQuality Characteristics of Potato Slices during Drying by Infrared Radiation Heating Method under Vacuum. The effect of drying behavior on the drying rate and quality characteristics of potato slices in a vacuum- infrared drying system was studied. In this work, the effect of the infrared radiation powers and vacuum levels at different slice thickness on drying rate and shrinkage percentage and rehydration capacity was investigated. From the study, it was concluded that IR power level has a significant effect on processing time and drying rate. With increasing radiation power, time drying is reduced and consequently drying rate is increased. The drying rate curve of potato slices at initial drying time is in the ascending phase because of surface moisture evaporation and after this phase due to the start of influence of water from within of material to surface descending phase occurs. Also, shrinkage percentage increased with increase of sample thickness. In other words, shrinkage was decreased at different thickness with an increase of infrared radiation power and vacuum level. It was discovered that the long period of drying and increase of sample thickness may have contributed to a decrease in rehydration capacity. Because of porous texture of potato, as soon put in boiling water for 3 minutes, the water absorption process quickly started and before the insert damage to product tissues, to maximum amount of water absorption will reach. The results also showed that with increasing shrinkage, rehydration capacity was decreased.

Samira et al [6] performed Mathematical modeling ofdrying of potato slices in a forced convective dryer based on important parameters.The effect of air temperature, air velocity, and sample shapes (circle and square with the same cross-sectional area) on kinetic drying of potato slices in a tunnel dryer was investigated experimentally and a suitable drying model was developed. The experiments of drying of potato slices were conducted at an air temperature of 45–70°C with an air velocity 1.60 m/s and 1.81 m/s. Results showed that drying temperature was the most effective parameter in the drying rate. The influence of air velocity was more profound in low temperature. The time for drying square slices was lower compared to the circle ones. Furthermore, drying data were fitted to different empirical models. Among the models, Midilli–Kucuk was the best to explain the single layer drying of potato slices. The parameters of this model were determined as functions of air velocity and temperature by multiple regression analysis for circle and square slices. Various statistical parameters were examined for evaluating the model.

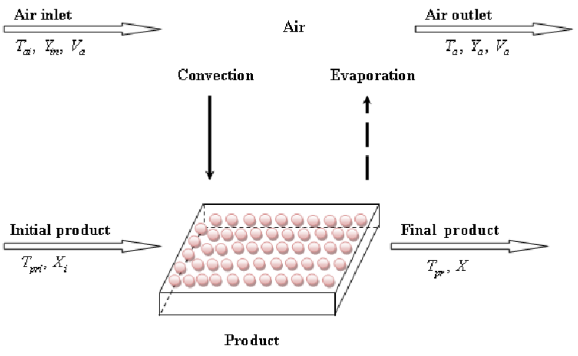

Fig.1 Flow diagram of drying process

Tatjana et al [7] studied Potatoes Drying Dynamics Research.In this study was investigated the slices thickness and temperature effect on the potato drying process. The experiments were carried out with potato slices of four different thickness 5 mm, 10 mm, 15 mm and 20 mm on laboratory conditions. There are compared drying processes by three different drying temperatures: 65, 75 and 85 ºC with the purpose to investigate slices thickness and temperature effect on the potato drying process. Using the experimental data the theoretical drying coefficient and diffusion coefficient were calculated. The results of this research showed that the diffusion coefficient is directly proportional to the moisture content in material. Its dependence can be described by linear equation. The linear equation constant shows the effect of drying temperature on the diffusion coefficient value. The theoretical results are useful for description and modeling of the drying process with time dependent drying coefficient and diffusion coefficient for potato slices and pieces on two- and three-dimensional case. Calculated parameters can be used for further research work and for improvement of the whole drying process.

Senadeeraet al [8]performed Mathematical Modeling of Time Based Shrinkage Constant in Fluidized Bed Drying.Experiments were undertaken to study relationship between time and shrinkage constant of food products during drying. Three particular geometrical shapes of parallelepiped, cylindrical and spheres were selected from potatoes (aspect ratio = 1:1, 2:1, 3:1), cut beans (length: diameter = 1:1, 2:1, 3:1) and peas respectively. Time dependent volumetric shrinkage behavior of food particulates was studied in a batch, fluidized-bed dryer connected to a heat pump dehumidifier system. Shrinkage constant was evaluated with time at three different drying temperatures of 30, 40 and 50°C. Relative humidity of hot air was kept at 15±5% in all drying temperatures. Time based volumetric shrinkage coefficient was modeled and found to vary with drying temperature and sample proportion.

Akpinar et al [9] studied Single layer drying behaviour of potato slices in a convective cyclone dryer and mathematical modeling.The main objective experiment is to investigate the single layer drying behavior of potato slices experimentally in a convective cyclone dryer and also to perform mathematical modeling by using single layer drying models in the literature. Drying experiments of potato slices with the thicknesses of 12.5 and 8 mm were conducted at inlet temperatures of drying air of 60, 70 and 80 ^{0}c and with drying air velocities of 1 and 1.5m/s. It was concluded that potato slices with thickness of 12.5mm would dry perfectly in the range of 460–740 min, while those with thickness of 8 mm would dry in the range of 280–520 min in these drying conditions in the convective type cyclone dryer. Additionally, the mathematical model describing the single layer drying curves was determined by non-linear regression analysis, and an approximation of the diffusion model was selected as the most suitable model to describe the drying curve equation of potato slices.

Shiva et al [10] performed Mathematical modeling and experimental analysis of potato thin-layer drying in an infrared-convective dryer.In this paper, the thin layer potato drying process by a laboratory scale infrared-convective dryer is investigated. The experiments were accomplished in three levels of slice thickness; 3, 5 and 7 mm, and three levels of infrared power; 500, 700 and 900 W. Drying took place entirely in the falling rate period. The results show that increasing the infrared power leads to a decrease in the moisture content, and drying time of samples, but increased the drying rate, shrinkage, and effective moisture diffusivity. The results also indicated that by increasing the thickness, the effective moisture diffusivity and drying time increased while the drying rate and shrinkage decreased.

R. Amiri Chayjan et al [11]performed Modelling Some Drying Characteristics of High Moisture Potato Slices in Fixed, Semi Fluidized and Fluidized Bed Conditions.Drying properties of high moisture potato slices with initial moisture content of about 4.06 (dB) under thin layer fixed, semi fluidized and fluidized bed conditions were studied. Drying air temperatures of 40, 50, 60 and 70°C were applied in experiments using a laboratory fluidized bed convective dryer. In order to predict the drying behaviour of potato slices, seven thin layer drying models were applied from where finally Madill model was selected as the suitable one based on comparative indices. Effective moisture diffusivity of the potato slices varied between 4.29×10-9 and 15.70×10-9 m^2/s for fixed and fluidized bed conditions, respectively. Moisture diffusivity values of the slices were increased as the drying air temperature levels increased. Activation energy values varied between 15.88 and 24.95 kJ mol-1. Minimum and maximum values of activation energy were obtained at minimum fluidized and fixed bed conditions, respectively. Consumption of specific energy for thin layer drying of high moisture potato slices was obtained between 0.45×105 and 1.64×105 (kJ/kg). Increase in the drying air temperature in each bed condition caused increase in energy consumption. The maximum value of energy consumption was obtained at fluidized bed conditions.

L. M. Diamante et al [12] performed Mathematical modelling of hot air drying of sweet potato slices.in this experiments the effect of air dry bulb temperature, air relative humidity, and air velocity and sample thickness on the thin-layer air drying of sweet potato slices was investigated. The drying rate curves consisted of two approximately linear falling rate periods and contained no constant rate period. Several mathematical models were fitted to the drying rates of sweet potato slices under a range of drying conditions. It was found that the modified Page equation best described the thin-layer air drying of sweet potato slices down to a moisture content of 10% dry basis. Correlations were also determined for the slope and intercept of the modified Page equation in terms of the experimental variables.

Mortaza Aghbashlo et al [13] performed Modeling of thin-layer drying of potato slices in length of continuous band dryer. In this experiment the thin-layer drying behavior of potato slices in a semi industrial continuous band dryer. Potato slices with thickness of 5 mm were used for drying experiments. The experiments were done at air temperatures of 50, 60 and 70 ^{o} C, air velocities of 0.5, 1 and 1.5 m/s and chain linear velocities of 1.85, 10, 4, 2.22, 10, 4 and 2.78 ,10,4 m/s. Three drying models were fitted to the experimental data of moisture ratio in order to assess a suitable form of the drying curve for potato drying. The Page model was selected as the best according to R^2, v^2 and RMSE.

Table1.Studies conducted on potato drying

Product	Drying process	Process Condition				Reference
		Temperature(^{o}c)	Velocity (m/s)	Thickness(cm)	Shape	
Potato	Convective	60	0.5, 1.0, 1.5, 2.0, 3.0, 4.5, 7.0, 8.0, 10.0	1	cube	[4]
	Infrared	100	0	0.1,0.2,0.3	slice	[5]
	Convective	45 to 70	1.60,1.81	0.7	circle ,square	[6]
	Convective	65,75,85	0	0.5,1,1.5,2	slice	[7]
	Convective	30,40,50	2.2	0.65	parallelepiped	[8]
	Convective	60,70,80	1,1.5	0.8,1.25	slice	[9]

	Infrared		0	0.3,0.5,0.7	slice	[10]
	Convective	40,50,60,70	1.53,4.12	0.3	slice	[11]
	Convective	50,60,70	0.5,1,3	03,0.6,0.9	slice	[12]
	Convective	50,60,70	0.5,1,1.5	0.5	slice	[13]

III. SUMMARY

The main points of summary, which may be drawn from the literature review, are listed below:

1. **Effect ofairtemperature**

Dryingtimedecreasesanddryingrateincreaseswithtempera ture. The effect of temperature on drying process at first stage is great. This behavior is attributed to the fact that driving force for evaporation of water from the samples increases by heating the sample.The results show that the increment in drying rate of potato with air temperature in low air velocity is more than that in high air velocity. Drying rate increase with increase in temperature

2. **Effect air velocity**

It is found that drying rate is increased with air velocity**.**The resistance to mass transfer is mixed in the potato samples and in the external layer. Thickness of the boundary layer and thus the mass transfer resistance in the gas phase decreases with blowing airflow on the sample and increases drying rate consequently. Toward the end of the drying, the effect of air velocity would become negligible because of the greater internal resistance to moisture transfer caused in part by structure changes.

3. **Effect of sample shape**

The shape parameter has much influence on drying rate.Although the cross-sectional area is considered equal in both samples, lateral surface area of the square sample is more than that in circle sample. This would increase the surface exposed with airflow and increase the evaporation rate consequently. In addition the ratio of perimeter to cross-sectional area for square shapes is more than circle. This increases the heat transfer and since the temperature in the drying was most effective parameter, mass transfer increases.

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