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Research Article

Investigation of Sample Sizes and Temperature Dependence of Krischer Curve (Drying Flux) in Drying of Yam Sample

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Abstract The effect of some variables such as sample size and drying temperature were studied at constant airflow velocity and humidity. The krischer curve was plotted for yam samples of 2 mm, 4 mm and 6 mm thickness at drying temperature of 40 ^{o}C and 60 ^{o}C. The study shows that the highest flux recorded was 5.2 g/min which occurred at the initial drying of sample size 2 mm thick, at the drying temperature of 60 ^{o}C. The results clearly show that at constant air flow rate, the drying flux increases with rise in temperature and reduction in sample thickness.

Keywords Krischer Curve, Temperature, Thickness, Drying Time, Moisture content

Introduction

The principal aim in a drying operation is the supply of heat required to provide the best product quality with minimum energy consumption. Heat absorbed by the product supplies the energy necessary for the vaporization of water from the surface of the product. When the absorbed energy has increased to the limit that water vapor pressure of the product moisture will be higher than the vapor pressure of the surrounding air, water from the surface of the moist product starts to vaporize. This leads to a subsequent decrease in the relative humidity of the drying air, increasing its moisture carrying capacity and ensuring sufficiently low equilibrium moisture content [1]. The nature of the product and its moisture content greatly affect the process of moisture immigration to the surface.

Although economic aspects necessitate maximum drying rates, however the product quality must be considered [2]. Some physical properties of the product to be dried (size, density, etc.), moisture content and mass-heat transfer coefficients between the air and the product, all vary during the drying process. Further, drying process is affected by the conditions external to the product such as temperature, humidity and mass flow rate of the drying air and also by changes in the chemical composition of the product to be dried (if any). Temperature of the drying air is a critical factor which affects the drying process. Maximum allowable temperature will exist for each product. This temperature is usually 15-20 °C higher than the ambient temperature. If the surrounding air is humid, then drying will be slowed down. Increasing the air flow, however, speeds up the process by moving the surrounding moist air away from the product. So, a well-designed dryer implies utilizing maximum energy and producing maximum air flow rate while maintaining the optimum temperature inside the dryer.

A lot of experimental and theoretical investigations have been conducted for the technical aspects and development of various types of dryers.

Kemp I C. in 2001, studied sludge characteristics curves under different conditions of air (temperature, relative humidity, and velocity). He concluded that this simplified method makes it possible to simulate the experimental kinetics satisfactorily [3].

The results showed that Midilli et al. model was found to satisfactorily describe the drying characteristics of poplar wood particles dried at all temperatures and air flow velocities. In general, the drying rate increases with increasing air temperature and air flow velocity.

For each sample, three curves have been plotted: the loss of mass Malong time, the evolution with time of the water mass flux ṁ across the drying surface Sand Krischer's curve, that is to say that same flux but in function of the water content (in kg/kg) ṁ is computed as :

$$\dot{m} = \frac{1}{s}\frac{dM}{dt}$$

Due to the frequency of the mass measures and the limited precision of the weighting scale, this flux undergoes many irregularities.

Hamid Z. H. et al, in 2012 studied the Krischer curves for wood particles at different drying air temperatures concluded that the Midilli *et al*. model is quite suitable for predicting the drying curve behavior of poplar wood particles in the temperature range of 65-85 °C. Effective moisture diffusivity of poplar wood particles increases with increasing air temperature and air flow velocity in the range of $1.0*10^{-10}$ to $2.5*10^{-10}$ m^2/s [4].

The krischer curve is a measure of drying flux against moisture content; the curve shows the dependency of a rate of drying on moisture content of any sample in a drying experiment. At constant drying conditions one would expect drying rate to be higher at initial period of drying due to higher moisture content, which will continue to decrease steadily as drying continues till the moisture content is reduced to zero.

In this work, the investigation is on how does the krischer curve depend on the temperature and sample thickness while other variables such as air velocity and humidity are kept constant.

Material and Methodology

Materials

Laboratory Weighing balance, Knife, Ruler, Multipurpose food dryer, yam sample of thickness 2mm, 4mm, 6mm, stop watch.

Methodology

The yam samples of various thicknesses were spread on different trays of the dryer. The mass of the empty trays and when loaded were taken at the beginning of the experiment. The ambient temperature and the time taken by the dryer to heat the air in the system to reach the temperature set point of 60 ^oC were recorded at the start of the experiment. As the drying proceeds the weight of the various samples were taken at every fifteen minutes interval and recorded until constant weight were recorded for three consecutive times.

The same procedure was repeated for drying temperature of 40 ^oC.

Figure 1: Yam sample before the experiment

Figure 2: Tray loaded with yam sample

Figure 3: Arrangement of the loaded trays on the dryer

Figure 4: Yam sample after the experiment

Results and Discussion

At 40°			
Moisture content, (%)	6mm Drying Rate (g/min)	4mm Drying Rate (g/min)	2mm Drying Rate (g/min)
60.1	0	0	0
59.2	0.7	1.6	2.3
58.2	0.8	1.4	2.2
56.9	0.9	1.4	2.5
55.9	0.7	1.2	1.9
54.5	0.9	1.2	1.6
53.3	0.7	1	1.1
52.3	0.6	0.9	0.9
50.8	0.9	1	1.1
49.7	0.6	0.7	0.5
48.5	0.6	0.9	0.7
47.2	0.7	0.8	0.6
46	0.5	0.5	0.5
44.7	0.6	0.6	0.4
43.4	0.5	0.4	0.4
42.3	0.5	0.5	0.2
40.8	0.6	0.6	0.4
39.7	0.4	0.3	0.3
38.2	0.5	0.4	0.3
37	0.4	0.3	0.1
36.2	0.3	0.3	0.2
35	0.4	0.3	0.1
34.4	0.2	0.3	0.2
32.8	0.5	0.4	0.4
31.7	0.3	0.3	0.3
30.5	0.3	0.3	0.3
29.3	0.3	0.3	0.3
28.2	0.3	0.4	0.2
27.2	0.3	0.3	0.1
26.1	0.3	0.3	0
25	0.3	0.3	0
24.2	0.2	0.3	
22.7	0.3	0.3	
20.9	0.4	0.2	
18.9	0.4	0.1	
16.9	0.4	0.1	
15.2	0.3	0	
13.7	0.3		
12.2	0.3		
10.2	0.3		
8.2	0.3		
6.4	0.3		
5.1	0.2		
4.2	0.1		
3.3	0.1		
2.3	0.1		
1.4	0.1		
0.8	0.1		
0.6	0		
0	0.1		
0	0		

At 60°			
Moisture content, (%)	6mm Drying Rate (g/min)	4mm Drying Rate (g/min)	2mm Drying Rate (g/min)
60.1	0	0	0
59.2	1.6	2.6	5.2
58.2	1.5	2.6	3.6
56.9	1.3	1.8	2.8
55.9	1.4	1.8	2.2
54.5	1.2	1.8	1.6
53.3	1.4	1.4	1.3
52.3	0.9	1.2	0.9
50.8	1.8	0.9	0.3
49.7	0.2	1.2	0.7
48.5	0.1	0.7	0.4
47.2	1.4	0.5	0.3
46	0.7	0.5	0.2
44.7	0.8	0.5	0.2
43.4	0.5	0.5	0.1
42.3	0.3	0.3	0.1
40.8	0.5	0.3	0.1
39.7	0.5	0.3	0.1
38.2	0.4	0.2	0.1
37	0.3	0.2	0
36.2	0.3	0.2	0
35	0.6	0.2	
34.4	0.6	0.1	
32.8	0.5	0.1	
31.7	0.3	0.1	
30.5	0.3	0	
29.3	0.2	0	
28.2	0.2		
27.2	0.1		
26.1	0.1		
25	0.1		
24.2	0		
22.7	0		
20.9			
18.9			
16.9			
15.2			
13.7			
12.2			
10.2			
8.2			
6.4			
5.1			
4.2			
3.3			
2.3			
1.4			
0.8			
0.6			
0			
0			

Figure 5: Table of the Experimental Data [5].

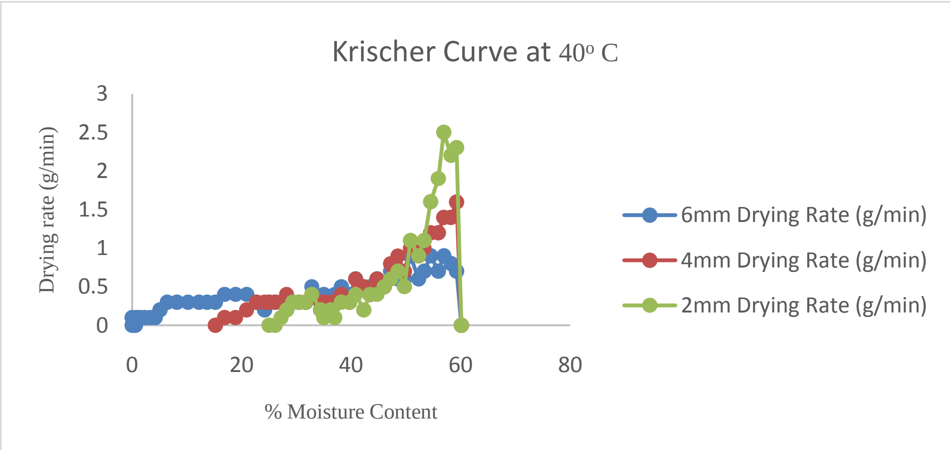

Figure 6: Krischer Curve at 40 °C

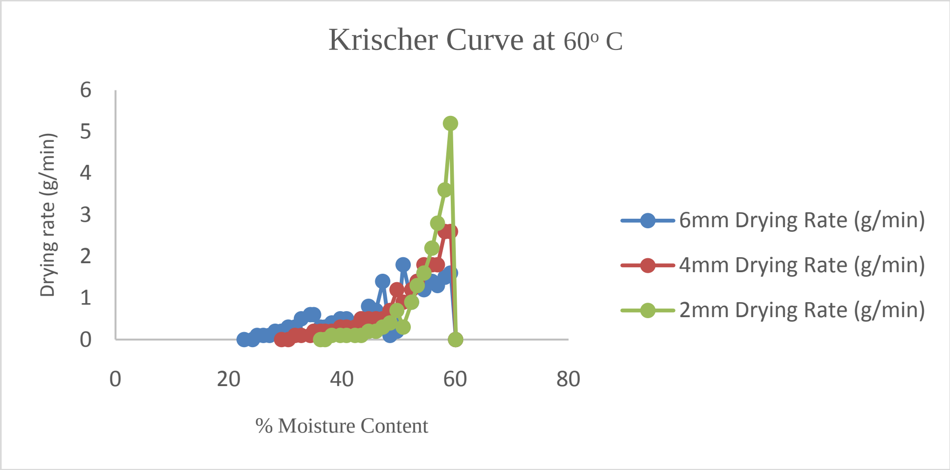

Figure 7: Krischer Curve at 40 °C

The krischer curve (figures 6 and 7) is a measure of drying flux against moisture content; the curve shows that the rate of drying was low at low moisture content and high when the water content of the sample was high. At around 60% moisture content the drying flux record the maximum values. In figure 6, the plot shows that at 40°C drying temperature, sample sizes of 2mm, 4mm and 6mm has a drying flux of 2.5, 2.3 and 0.9g/min respectively at initial moisture content of 60%. While in figure 7, the same sizes of 2mm, 4mm and 6mm at 60° C has a drying flux of 5.2, 2.8 and 1.8g/min respectively at initial moisture content of 60%. The results clearly show that at constant air flow rate, the drying flux increases with rise in temperature and reduction in sample thickness. It can be deduced that if other conditions remained constant drying flux increases with reduction in sample thicknesses and vice versa.

Conclusion

The investigation shows that the Krischer curve is a function of the drying temperature and sample thickness at a constant air flow velocity. The flux is highest at initial period of the experiment when the moisture content is very high. The Krischer plot clearly shows that the drying flux is directly proportional to the moisture content. It can be deduced that if other conditions remained constant, drying flux increases with reduction in sample thicknesses and vice versa. The highest flux recorded was 5.2g/min which occurred at the initial drying period of sample size 2mm thick, at the drying temperature of 60° C. The results clearly show that at constant air flow rate, the drying flux increases with rise in temperature and reduction in sample thickness.

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