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Original Research Article

Effect of Some Parameters on Moisture Removal from Food Samples

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Abstract: The parameters investigated in this experimental work were drying temperature; air velocity, relative humidity and the thickness of the samples. Yam thickness of 2, 4 and 6mm were investigated at temperature of 40, and 60^{o}C while every other condition such as relative humidity and hot air velocity were constant. The rate of drying is a function of the sample thickness, drying temperature provided that the air velocity and relative humidity are constant. The sample of thickness 2mm had the shortest drying time at various temperature ranges investigated comparing with the other sample sizes. It can be depicted that the thicker the sample the longer it takes to dry for the same sample at the given temperature. The plots show that there was initial high rate of evaporation when the water content of the yam was very high. The rate of drying is a function of the sample thickness, drying temperature provided that the air velocity and relative humidity are constant. The thickness of the sample and drying temperature has direct relationship with the drying time. It can be depicted that the thicker the sample the longer it takes to dry for the same sample at the given temperature.
Keywords: Temperature, Thickness, Drying Time, Moisture content, Air velocity

INTRODUCTION

The principal aim in a drying operation is the supply of heat required to provide the best product quality with minimum energy consumption. There are two techniques for drying of food staff namely, open sun drying and solar drying in a drying system. 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 [3]. 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. There are various criteria by which dryers can be classified. They include; mode of operation (batch and continuous), heat input mechanism (convection, conduction, radiation and combination of heat transfer modes), state of material in the dryer (stationary, moving, agitated and dispersed), operating pressure (vacuum and atmospheric), drying medium (air, superheated steam, flue gases), relative motion between drying medium and drying solids (parallel, counter-current, mixed flow), and adiabatic or non-adiabatic.

The multipurpose dryer is a batch convective dryer using heated air as the drying medium and operating in batch wise mode. The dryer is a direct heat tray type achieving heat exchange through direct contact between the hot air and the material to be dried. The dryer is designed to operate under adiabatic condition. The gas/solid contacting pattern in the dryer is parallel flow in which the direction of air flow is parallel to the surface of the leaf bed. Contacting is primarily at the interface between the air phase and leaf bed, with possibly some penetration of air into the voids among the leaves near the surface. The leaf bed is in a static (stationary) condition.

Description of multipurpose dryer used in this experiment.

The dryer dimensions are 1.0 × 0.6 × 1.2 m. It is fabricated from metal sheet and the inside is made of composite material with insulator made of fiber grass of thickness 20mm.

The multipurpose dryer has metal frame structure which holds the four trays in position. The design is so flexible that it can be operated by one person.

MATERIAL AND METHODOLOGY

Materials

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

METHODOLOGY

The yam sample of various thicknesses was 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 50^oC and 40^oC on different days.

Fig-1: Yam sample before the experiment

Fig-2: Tray loaded with yam sample

Fig-3: arrangement of the loaded trays on the dryer

Fig-4: Yam sample after the experiment

RESULT AND DISCUSSION

Table-1: Moisture Contents at different temperature for different sizes of the food samples.

At 40°			
Time	2mm	4mm	6mm
0	60.1	60.1	60.1
15	57.1	58.1	59.2
30	53.9	56.2	58.2
45	49.5	54	56.9
60	45.6	52	55.9
75	41.9	49.9	54.5
90	39	47.8	53.3
105	36.5	46	52.3
120	33.1	43.6	50.8
135	31.3	41.8	49.7
150	28.6	39.6	48.5
165	26.3	37.3	47.2
180	24.3	35.8	46
195	22.5	33.9	44.7
210	20.7	32.6	43.4
225	19.8	31	42.3
240	17.8	28.8	40.8
255	16.4	27.5	39.7
270	14.6	25.9	38.2
285	13.9	24.5	37
300	12.8	23.4	36.2
315	12	22.2	35
330	10.8	20.7	34.4
315	12	22.2	35
330	10.8	20.7	34.4
345	8.4	18.8	32.8
360	6.3	17.1	31.7
375	4	15.8	30.5

At 40°			
Time	2mm	4mm	6mm
390	2.1	14.3	29.3
405	0.7	12.1	28.2
420	0.2	10.6	27.2
435	0	9	26.1
450	0	6.9	25
465		5.1	24.2
480		2.9	22.7
495		1.5	20.9
510		0.5	18.9
525		0	16.9
540		0	15.2
555			13.7
570			12.2
585			10.2
600			8.2
615			6.4
630			5.1
645			4.2
660			3.3
675			2.3
690			1.4
705			0.8
720			0.6
735			0
750			0

At 60°			
Time	2mm	4mm	6mm
0	60.1	60.1	60.1
15	52.8	56.7	58.1
30	46	52.8	56.1
45	38.9	49.5	54.1
60	31.9	45.7	51.8
75	25.8	41.5	49.6
90	20.2	37.7	46.8
105	15.9	34.1	44.8
120	14.1	31	40.4
135	9.9	26.4	39.8
150	7.4	23.7	39.5
165	5.6	21.3	35.4
180	4.3	18.8	33
195	2.9	16.1	30.2
210	2	13.2	28.2
225	1.5	11.7	26.9
240	1	9.8	24.7
255	0.5	7.7	22.7
270	0	6.5	20.9
285	0	5.1	19.6
300	0	3.8	18.3
315		2.4	15.2
330		1.5	11.8
345		0.5	9
360		0	6.9
375		0	5.2

At 60°			
Time	2mm	4mm	6mm
390		0	3.8
405			2.4
420			1.5
435			0.5
450			0
465			0
480			0

Table 1 above shows the experimental results obtained at different temperatures and time for different thicknesses [4].

The values of the percentage moisture content were plotted against the drying time. Figures 5 and 6 explains.

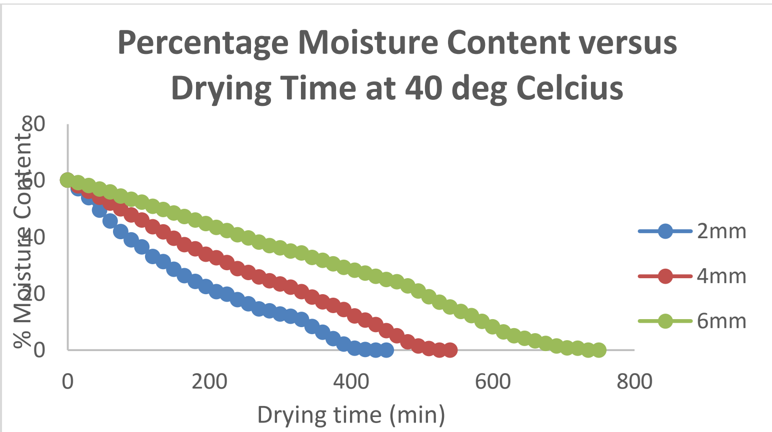

Fig-5: Percentage Moisture Content versus Drying Time at 40° C

The graph shows that moisture content for 2mm, 4mm and 6mm thickness reduces to zero at 450, 540 and 705 minutes respectively at 40° C. This shows that the thicker the sample the longer time it takes to dry.

The figures show that the rate of drying is a function of the sizes of the sample and temperature at constant fan speed. In figure 5 the 2mm, 4mm and 6mm dried after 450, 540 and 705 minutes at 40°C. While in figure 6, the samples (2, 4 and 6mm) dried after 300, 400 and 480 minutes at the drying temperature of 60°C. The figures show that the rate of drying is a function of the sample thickness and drying temperature at constant air velocity and air humidity. The plots show that there was initial high rate of evaporation when the water content of the yam was very high. The recommended 10% moisture content for the quality control and the preservation of the yam can easily be trace from the plots at various sample thickness sizes and drying temperatures for subsequent work. This can easily be traced from table 2 below. The table show clearly that the various sample size attain the 10% moisture content faster at a higher drying temperature. It also takes longer time for a thicker sample to attain the same 10% moisture content.

Mathematically, the rate of drying using a convective dryer,

Δm/Δt = f (Thickness, Temperature, air velocity v, relative humidity, H)

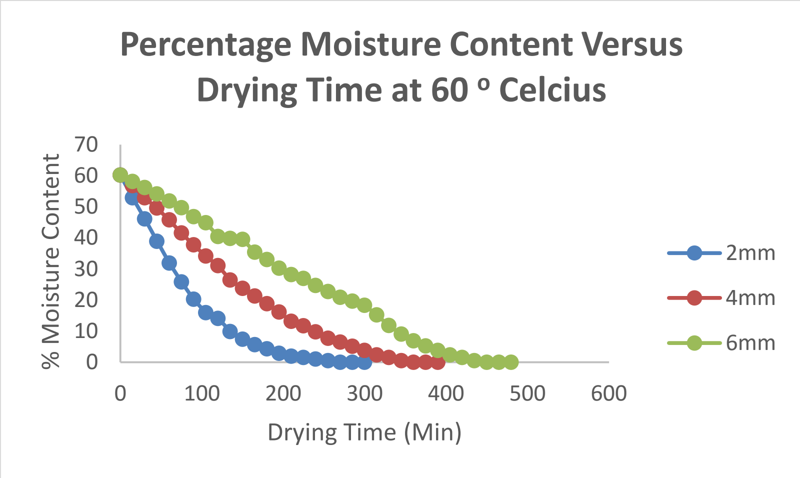

Fig-6: Percentage Moisture Content versus Drying Time at 60°C

Table-2: Time take by the samples to attain 10% moisture content at different temperatures.

Time at different temperatures (Min)	2 mm	4mm	6mm
Time to attain 10% Moisture Content 40°C	345	420	585
Time to attain 10% Moisture Content 50°C	240	340	
Time to attain 10% Moisture Content 60°C	135	240	345

CONCLUSION

Drying conditions such as sample thickness, drying temperature at constant relative humidity and hot air velocity has great effect on the drying of food samples. The rate of drying is a function of the sample thickness, drying temperature provided that the air velocity and relative humidity are constant. The thickness of the sample and drying temperature has direct relationship with the drying time. It can be depicted that the thicker the sample the longer it takes to dry for the same sample at the given temperature.

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