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Investigation of Drying Quality of Yam (A Staple Food) From Developed Multipurpose Food Dryer

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ABSTRACT

A multipurpose food dryer was developed to test dry a particular staple foods in this work. The principal aim in this operation is to make sure that the desired product (physical) quality, as well as the food chemical constituents-starch, protein, carbohydrate etc are not affected after drying. The drying conditions investigated were drying temperature on the various thickness of the sample. Yam thickness of 2mm, 4mm and 6mm were investigated at temperature of 40ºC, 50ºC and 60ºC while every other conditions such as relative humidity and hot air velocity were assumed constant. The rate of drying is a function of the sample thickness and drying temperature all in a closed system. Various samples of thickness were dried at various temperature ranges. The Krischer plots were used to depict the drying flux in relation to the moisture content. Laboratory investigations reveals that no coloration of the yam samples were recorded, whereas in some other modes of drying involving heating, the physical appearance such as colour were affected and further investigation reveals chemical constituents were maintained. This confirms that the dryer designed and investigated for functionality is very good for its purpose.

Keywords*:* *Temperature, Thickness, Krischer Curve, Moisture Content, Coloration*.

1. INTRODUCTION

The main aim in a drying operation is the supply of heat required to provide the best product quality with minimum energy consumption such as this case. There are two common techniques for drying of food stuff 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 a sufficiently low equilibrium moisture content.

The nature of the product and its moisture content greatly affect the process of moisture immigration to the surface cum drying time.

Although economic aspects necessitates maximum drying rates, however the product quality must be considered. 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.

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.

Brief Description of Dryer

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 yam bed.

Contacting is primarily at the interface between the air phase and yam bed, with possibly some penetration of air into the voids among the sliced yam near the surface. The yam bed is in a static (stationary) condition. The multipurpose dryer has metal frame structure which hold the four trays in position. The design is so flexible that it can be operated by one person.

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.

2. MATERIAL AND METHOD

2.1. Materials

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

2.2. Method

The yam sample 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 60ºC were recorded at the start of the experiment. As the drying proceeds the weight of the various samples were taken at intervals of fifteen minutes and recorded until constant weight were recorded for three consecutive times. The same procedure was repeated for drying temperature of 50ºC and 40ºC on different days.

Figure 2.1: Yam sample before the experiment

Figure 2.2: Tray loaded with yam sample

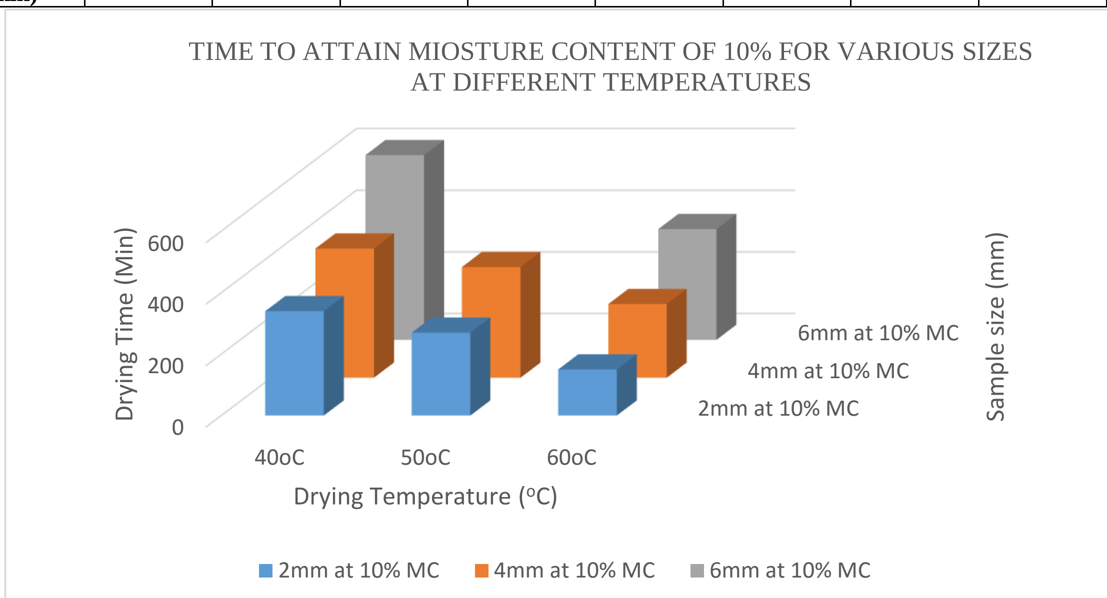
Fig: 2.3: arrangement of the loaded trays on the dryer.

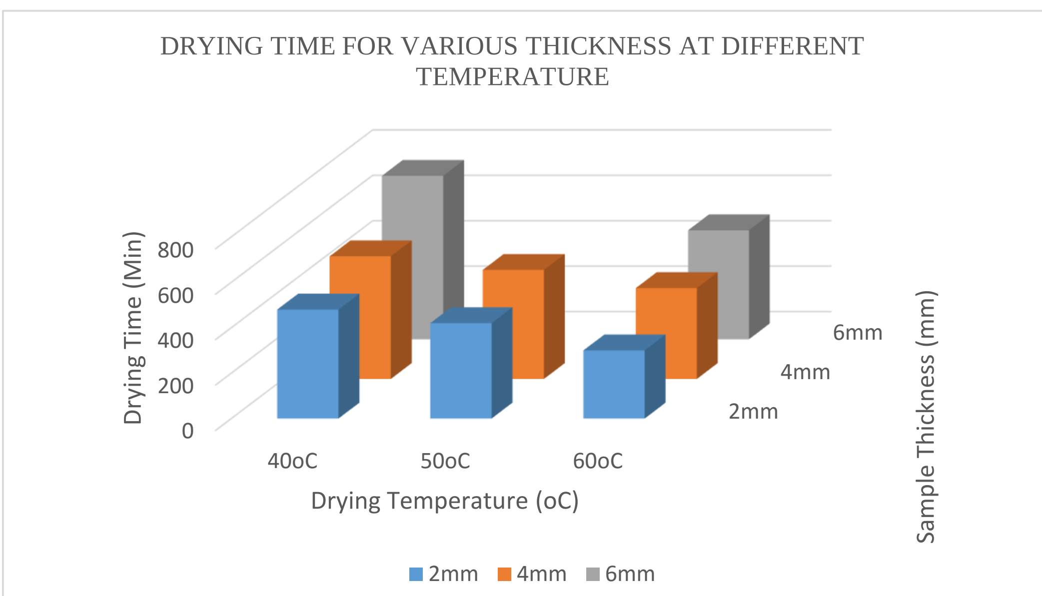
Fig: 2.4: Yam sample after the experiment

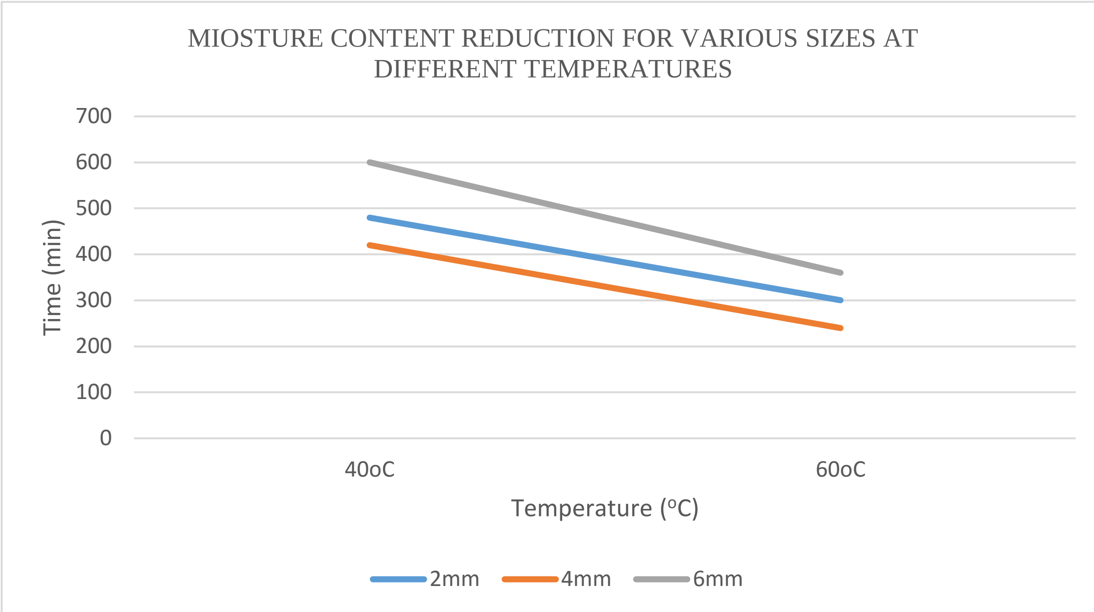
3. RESULTS AND DISCUSSION

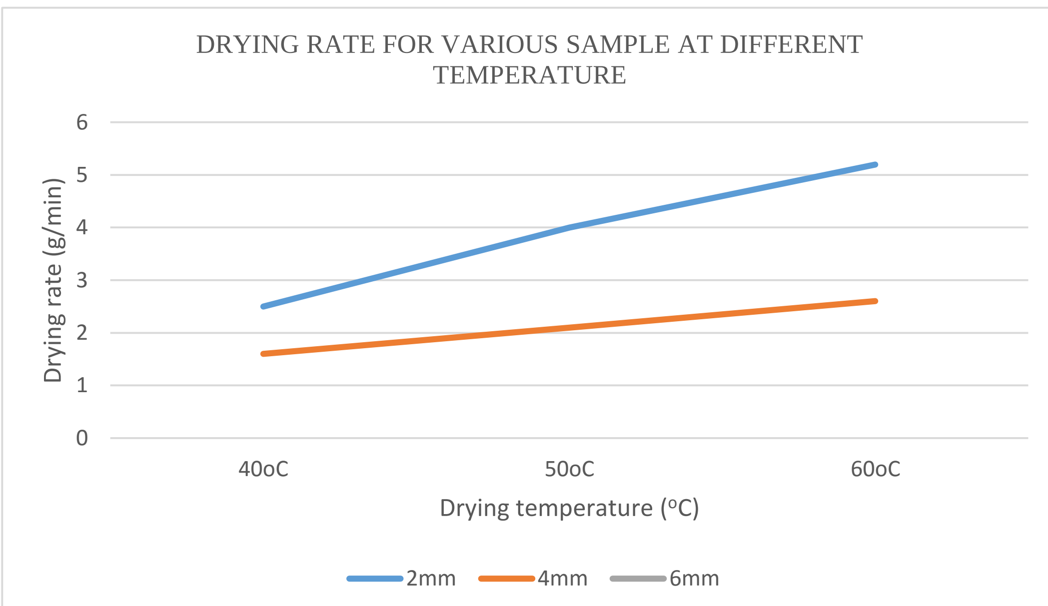
3.1: Comparison of various experimental results

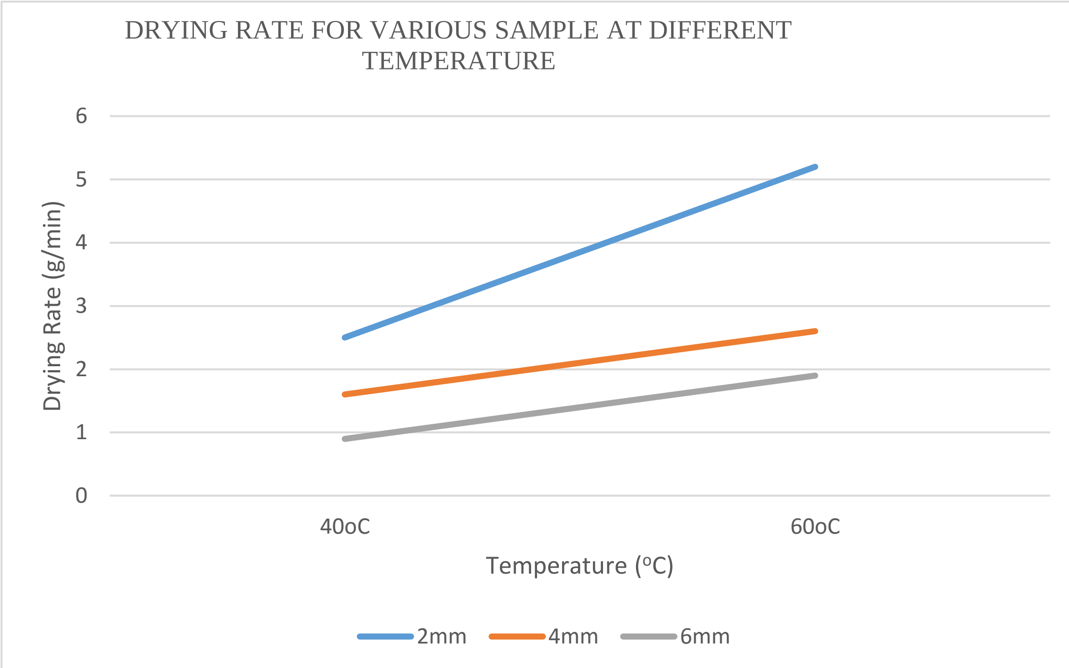
	EXP 1	EXP2	EXP3	EXP4	EXP5	EXP6	EXP7	EXP8	EXP9
Thickness (mm)	2.00	2.00	2.00	4.00	4.00	4.00	6.00	6.00	6.00
Tempt (°C)	60	50	40	60	50	40	60	50	40
Total Drying time (min)	300	420	450	390	480	540	480	-	750
Time @ 10% MC (min)	135	255	330	240	345	435	345	-	585
Maximum Drying Flux (g/min)	5.2	4.0	2.5	2.6	2.1	1.6	1.8	-	0.9

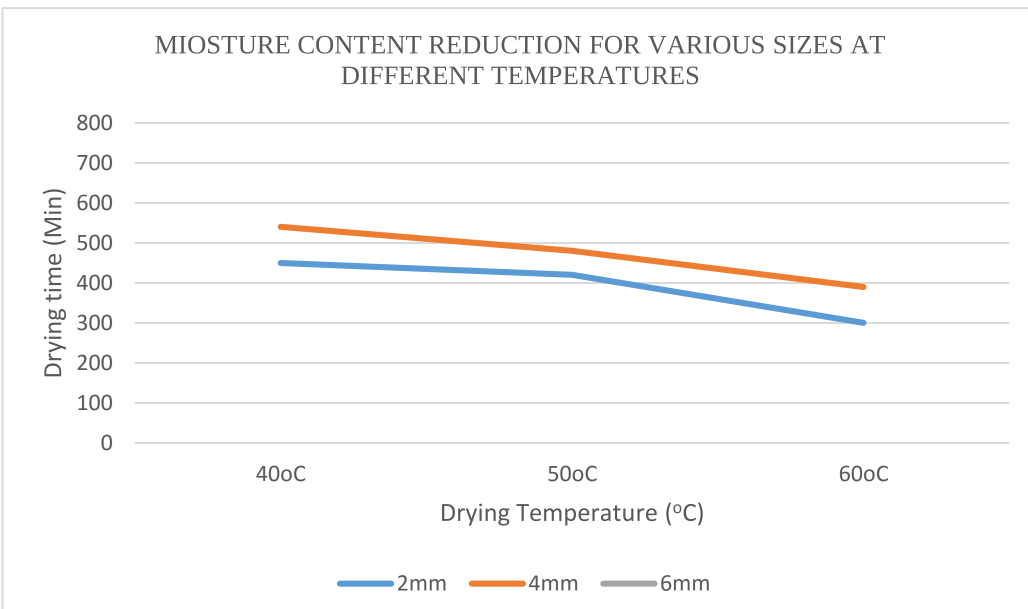





MIOSTURE CONTENT REDUCTION FOR VARIOUS SIZES AT DIFFERENT TEMPERATURES
Time (min)
700
600
500
400
300
200
100
0
40oC
60oC
Temperature (°C)
2mm
4mm
6mm


DRYING RATE FOR VARIOUS SAMPLE AT DIFFERENT TEMPERATURE
Drying rate (g/min)
6
5
4
3
2
1
0
40oC
50oC
60oC
Drying temperature (°C)
2mm
4mm
6mm





The drying conditions investigated were drying temperature and the thickness of the sample, thickness of 2, 4 and 6mm were investigated at temperature of 40, 50 and 60°C while every other conditions such as relative humidity air velocity were assumed constant.

Thickness of 2mm dried fastest at 60°C which took 300 minutes (5hrs) while at 50°C and 40°C took 420 minutes (7hrs) and 450 minutes (7.5hrs) respectively.

For the thickness of 4mm dried fastest at 60°C which took 390 minutes (6.5hrs) while at 50°C and 40°C took 480 minutes (8hrs) and 540 minutes (9hrs) respectively. The thickness of 4mm took additional 1.5hr, 1hr and 1.5hrs for 60°C, 50°C and 40°C respectively.

For 6mm thickness, the yam sample dried faster at 60°C for 480minutes (8hrs) than at 40°C which took about 750 minutes (12.5hrs). Taking the 2mm thickness as the basis the sample of 6mm at 60°C take additional three (3) hours to dry while the sample thickness take additional five (5) hours at 40°C.

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 dried fastest at various temperature ranges investigated than other sample sizes.

It can be depicted from the table 3.1above that the thicker the sample the longer it takes to dry for the same sample at the same temperature.

Other investigations include the time taken by various sample thickness at different temperatures to attain 10% moisture content as shown in the table above. It is also important to note the physical appearance remain whitish and unchanged even after months of the experiment.

4. CONCLUSION

Drying conditions such as sample thickness, drying temperature at constant relative humidity and hot air velocity has great effect on the efficiency and effectiveness of food dryers. 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.

The Krischer plot clearly shows that the drying flux is directly proportional to the moisture content. It can be depicted that the thicker the sample the longer it takes to dry for the same sample at the given temperature.

Investigation has revealed that the developed dryer is very good and conforms to the necessary drying conditions required by the client.

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