IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 10, Issue 9, September 2020, ||Series -I|| PP 30-34

Evaluation the effects of thickness, sharpness, surface exchange area and moisture content of hygroscopic products during the kinetics drying process

CU Thi Thanh Huyen[1], NGUYEN Hong Quan[2], VU Thi Tuyet Hong[2], NGO Anh Tuyet[3]

[1]*Institute of Energy Science, Vietnam Academy of Science and Technology, Vietnam*
[2]*University of Science and Technology of Hanoi (USTH), Vietnam*
[3]*Electric Power University, Vietnam*
Received 02 September 2020; Accepted 18 September 2020

Abstract: Drying operations play an important role in food industries. They are often the last step of the process manufacturing a product with a strong influence on the final quality. The drying relates to a wide variety of products. Methods are many and depend on the type and quantity of product to be dried and of water to be evaporated, the desired final quality, or functionality sought for the dried product.The study considers to different experiment: nutritional fruits (Mangoes, Bananas) and sand which is normal used as the draining porous media in traditional agriculture drying process. All three samples of fresh Mangoes (including two same thickness and sharp samples, the other one with different sharp),two samples of fresh Bananas with different surface exchange area, three samples of sand (with two same thickness and different moisture content, the other one with different thickness but same moisture content) are drying in the oven at 70^0C temperature. The result data has been recorded to plot curves and estimate. This gives a few to understand the theory of drying kinetics and provide information useful in dryer design.
Keywords: Drying, kinetics, water content, moisture content, hygroscopic products.

I. INTRODUCTION

Fruits properties are related to the complexity of their composition chemical (sugars, proteins, lipids, minerals, vitamins, flavors, ...) which evolves during drying and must be controlled. Therefore, we must take into account changes in the sharp, thickness, surface exchange area and water content and many other factors that have positive or negative effects.In this work, we chose Mangoes and Bananas which are some of the most significant fruits grown throughout the tropical countries. They contain in many nutritive elements. To preserve the high produced quantity, the producers generally in dried them by many methods. After being harvested, these products are cut in various sizes and displayed directly in the sun or transport to the factories with drying machines. We also chose sand which is normal used as the draining porous media in traditional agriculture drying process. It helps increase the thickness of drying products and reduce energy and of course reduce the cost.In this drying practice, we point up the influences of sharp, thickness, surface exchange area and moisture content in kinetic drying process through the drying curves. The parametric study was carried out in different sharp of Mangoes, in different thickness of all types of sample, in different moisture content of sand at 70˚C. The goals of this work therefore is to understand about theory drying and to give some comment for dryer design.

II. MATERIAL AND METHOD

2.1 Material

Vietnam is an agricultural country, located in the hot and humid tropics, with the types of fruits are quite plentiful. At present, the output of banana and mango are quite large, the purpose of researching drying technology is suitable for these two fruits to save most energy. Therefore, the materials which we used in this studyinclude fresh mangoes, sand and bananas.

Fresh mango and banana are samples we prepared and bought at the market. We then peeled these fruits and cut them into different sizes and placed them in trays of corresponding thickness.In preparation for the steps of implementing our research process on effects of thickness, sharpness, surface exchange area and moisture content of hygroscopic products during the kinetics drying process

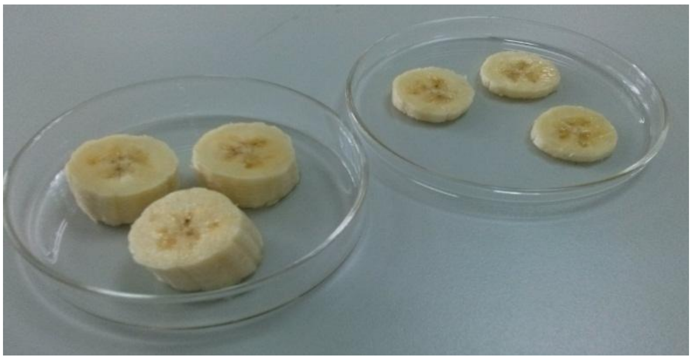

Figure 1. Banana sample used for drying

Sand was taken from a constructing building. The dry sand sample was put into a glass container.Dry and wet sand have been cleaned with fresh water. Then they are put into two glass boxes, determined by weight and determined thickness of sand before drying.

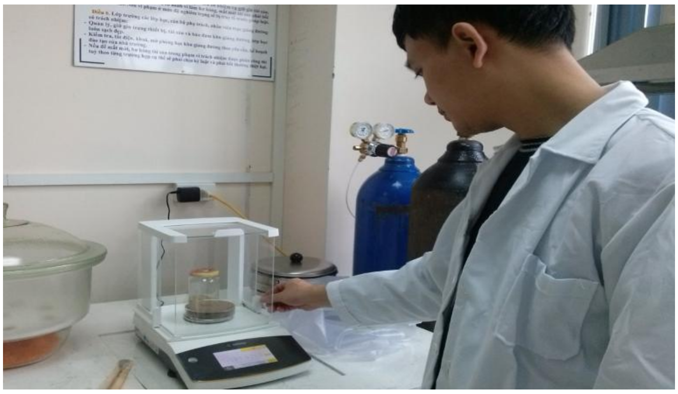

Figure 2. Dry sand sample used for drying

		Details	Support(g)	Initial(g)
Mangoes	Sample 1 (g)	Slice e = 0.95 cm	40.44	23.767
	Sample 2 (g)	Slice e = 0.5 cm		12.516
	Sample 3 (g)	Cubic (2.05x2.27x2.25)		10.463
Sand	Sample 4 (g)	Wet sand e = 2.06 cm	46.3	127.138
	Sample 5 (g)	Dry sand e = 1.13 cm	40.52	70.566
	Sample 6 (g)	Wet sand e = 1.13 cm	40.52	116.822
Banana	Sample 7 (g)	Cylinder: d = 2.81 cm e = 4.25 cm	2.108	6.854
	Sample 8 (g)	Cylinder: d = 2.67 cm e = 3.52 cm	1.142	6.177

Table 1. Present initial data of samples

Each fruit and sand in our experiment will be prepared into 3 samples. Each sample has a different thickness and length. Corresponding to the initial weight determined before drying.

For mango fruit, sample 1,2 is sliced with thickness of 0.95cm and 0.5cm. At the same time we create a cubic (2.05x2.27x2.25) for sample 3.As for sand, we use two types: wet sand and dry sand. In which we create 3 patterns with different thickness. Wet sand has e = 2.06 cm, e = 1.13 cm and dry sand has e = 1.13 cm. For a comparison between dry and wet sand for the same temperature and thickness we dried them.

The bananas are cylindrical and we have different thicknesses. Select 2 bananas with the diameter size d = 2.81cm and d = 2.67 cm with a thickness of 4.25 cm and 3.52 cm respectively.

2.2 Methods of study

The time required to achieve a desired state of dryness can be found by integrating the expressions for drying rate with respect to time. Under constant drying conditions and during the constant drying rate period:

$$N_c = -M_s \frac{dX}{dt}$$

As N_c and M_s are constant during constant rate drying, the only variables are X and t. Separating variables and integrating gives:

$$\int_0^{t_1} dt = \frac{-M_s}{N_c} \int_{X_0}^{X_1} dX$$

Or

$$\Delta t = \frac{M_s}{N_c}(X_0 - X_1)$$

The time required to dry sample from an initial moisture content of X_0 to a final moisture content of X_1 when the drying rate is constant. From the definition of drying, X_0 and X_1 are moisture contents expressed on a dry mass basis using units of, for example, kg kg^{-1} of dry solid.

During the falling drying rate period, the drying rate N is no longer constant. Equations for drying time during this period can be developed depending on the relationship between N and X and the properties of the solid. Kinetic models for predicting the drying rate curve, including during the falling rate period when internal heat and mass transfer mechanisms are limiting, are described elsewhere.

The drying equipment includes: The oven-dryer initially regulated at 70˚C, a precise digital scale, a clipper to measure thickness and a temperature Metter (with 2 probe). Using a clipper to measure dimensions of initial samples and a balance to measure weight of sample during drying process.

These measurements were done every 15 - 25 min during the first 95 min. Then, because of the drying rate decrease, measurements were taken every 30 min from 210 min to 330 min drying and finally at the last stage of drying 1320 min and 1680 min.

From the initial mass m_0 and dry mass ms, the initial water content of each sample was determined by the following equation:

$$X_0 = \frac{m_w}{m_s} = \frac{m_o - m_s}{m_s}.$$

where m_w is the mass of water inside the product.

The drying curves were established by measuring the mass *m(t)* of dry samples at any time. The mass value decreases in proportion as drying time increase. At the end, the product keeps its mass constant then the dry mass $m_s$is determined.

The water content at each instant of drying were determined:

$$X(t) = \frac{m(t) - m_s}{m_s}$$

Drying kinetics of dry samples were established by fitting *X(t)* versus drying time. Using the temperature metter to measure temperature inside product and temperature on the product surface.

III. RESULTS

Tested materials were sampled from three different sources: Mangoes, sand and banana. Each material will have 3 models of different sizes and weights. The selected materials cover a reasonably wide range.Table 1 summarizes the details and initial values determined for each sample of material.

For each material source, three test samples were prepared with random dry masses and initial moisture contents as mentioned in Table 1.Samples were subsequently introduced into the experimental setup and oven dried. Every 15 minutes, the oven was stopped for a few seconds in order to record the mass of the loaded experimental setup.At the end of each experiment, the dry mass m_s of the product was obtained by drying the sample in the oven dryer at 70˚C for 28 hours.

3.1 Moisture content change with different sharp, thickness, surface exchange area

The effect of sharp, thickness and surface exchange on the variation of the moisture content of the samples during the drying process was evaluated.

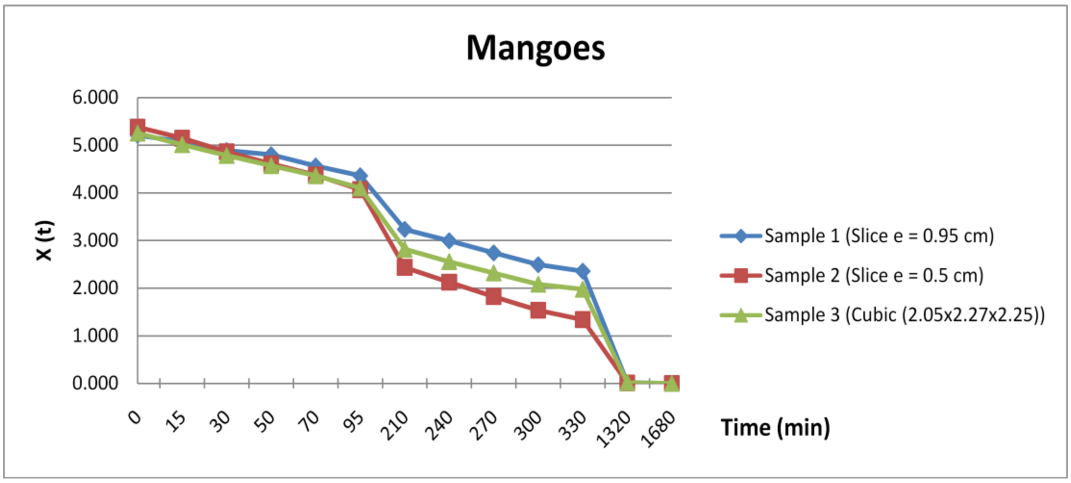

Figure 3. The drying curve for mangoes samples at 70˚C

The results in Figure 3 show that how the drying process is depending on the shape of product. With the same shape, more thickness the product has, lower drying process is. But if we change the shape of product, even the thickness is larger than before, the drying rate is not changed too much.

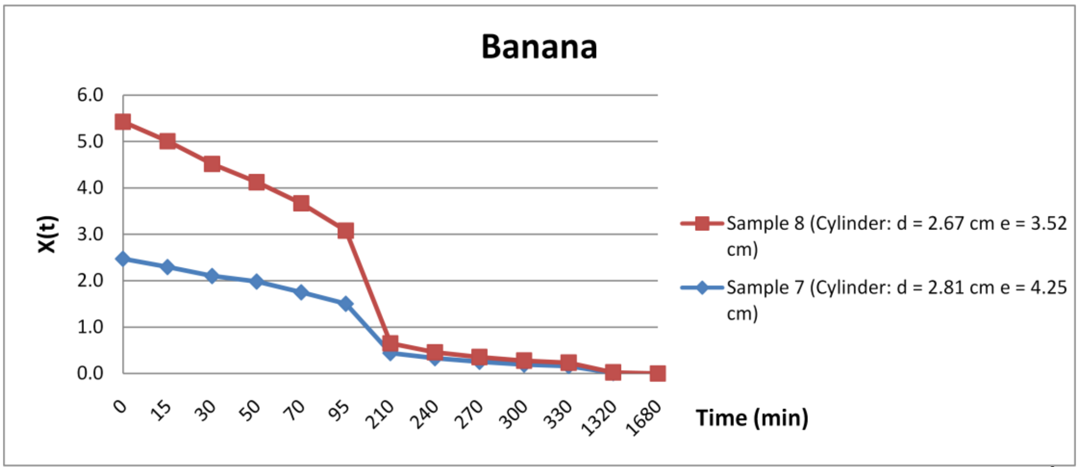

Figure 4.The drying curve of Banana samples with different surface exchange area at 70^{0}C

Figure 4 shows that sample 7 with surface exchange area = 43,72 cm^2> surface exchange area of sample 8 =35.125 cm^2 so the drying time of sample 7 longer than sample 8.That means the drying time increase as increase the surface exchange area of product.

3.2 Influence of initial moisture content in sand to its drying curves

The tray containing the wet sand layer and using with the thermocouple and a temperature recorder, are all placed on an electronic balance. In the experiment, the sand layer temperatures are recorded by the temperature recorder.The water contents are determined by time with different sand thickness corresponding to dry sand and wet sand.

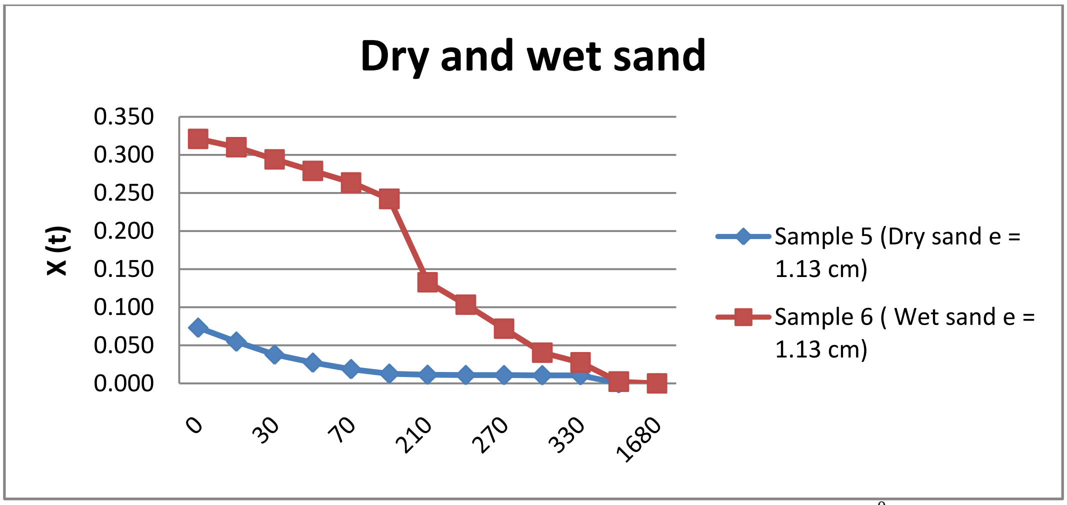

Figure 5.The drying curves for dry and wet samples at 70^{0}C

Figure 5 shows that the drying time of dry sample is smaller than wet sample.When the oven is heated, the temperature of the sand layer increases while the wilt of the surface sand decreases, the previous stage has the effect of increasing the drying speed while the next stage reduces the drying speed leading to the drying speed almost unchanged when the specified time is reached. Therefore, the initial water content had a significant influenceon the inherent structures, which couldaffect the ability of water flow in sand.

IV. CONCLUSION

The influences of sharp, thickness, surface exchange area and moisture content at 70^{0}C of drying air temperature for mangoes, bananas and sand was studied. The result allows predicting drying time according to sharp, thickness, surface exchange area and moisture content. A smaller thickness or surface exchange or moisture content area of at 70^{0}C of air drying is the smaller drying time. This study has therefore given a view to understand the theory drying and provided information useful in drying process design for mangoes, bananas and also for sand which will assist decrease cost of final product.In the practice we can't record exactly the temperatures because the probe temperature was out of the target. So we haven't got data to calculate heat and mass transfer.We will conduct experiments and use other equipment to gather more parameters, to expand our research content.

ACKNOWLEDGEMENTS

This paper was supported by the Institute of Energy Science, Vietnam Academy of Science and Technology, The University of Science and Technology of Hanoi and Electric Power University. We would like to extend our gratitude toour colleagues and scientists for their excellent comments on this article and hope to continue to receivecomments from these specialized experts in future articles.

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