Mysore J. Agric. Sci., 55 (1) : 46-51 (2021)

Studies on Drying Characteristics of Guava (*Psidium guajava*) under Different Drying Methods

MOHAMMAD AZAM AND SHEELA PANDEY
Deparment of Post-Harvest Process & Food Engineering, College of Agricultural Engineering
JNKVV, Jabalpur - 482 004 (MP)
e-Mail : mazam226@gmail.com

ABSTRACT

To study the drying characteristics of guava (*Psidium guajava*) various experiments using guava slices by three different drying methods namely, sun drying, shade drying and hot air drying were conducted. In the experiment 500g of guava slices were spread on trays in thin layer and then drying was done. The data were collected to notice the reduction in weight at different time intervals of (30, 60, 90, 120,180 and 360 minutes). The data obtained were used to develop the drying characteristics curve.

Keywords: Guava, Drying methods, Drying characteristics, Moisture ratio, Drying rate

GUAVA (*Psidium guajava*) is an important commercial fruit crop of tropical and subtropical world, where it also thrives well in the wild. Therefore, it is also known as 'Apple of the tropics' and has earned the popularity as 'Poor man's apple' due to its plenty availability and low cost to every person during the season. Being one of the most nutritious and delicious fruits with refreshing taste and pleasant flavor, guava is liked by the consumers. The total guava production in India is 3.20 million tons from an area of 0.24 million hectares and productivity of 13.6 t/ha (Kumari *et al*., 2020). Fresh guava has 228.3 mg 100 g^{-1} of ascorbic acid (vitamin C) and 5204 µg 100 g^{-1} of lycopene. Lima *et al*. (2019) reported about 2000 mg GAE 100 g^{-1} (Gallic acid equivalent) of total phenolic compounds. There are various benefits gained by consuming a diet rich in fruits with high antioxidant activity, such as reduction of oxidative stress, aid in the prevention of cancer, cardiovascular diseases, and complications of diabetes (Ribeiro *et al*., 2020). In this context, Guava, now being recognized as 'Super food' is getting very much attention in the agro-food business due to the attractive characteristics of the fruit, such as excellent digestive and nutritive value, pleasant flavor, high palatability and availability in abundance at moderate price (Gandhi and Singh, 2014).

The high water content of most fruits (over 80 %) makes them highly perishable and is responsible for post harvest losses in storage, handling and transportation, resulting in economic losses. Transformation to a stable product is thus necessary either by drying, canning or freezing.

Drying is one of the oldest and simplest methods of preservation, requiring little outlay of special equipment which preserves foods by removing enough moisture to prevent decay and spoilage (Shigihalli and Vijayalakshmi, 2018). Drying is a process of simultaneous heat and mass transfer. Heat required for evaporation is supplied to the particles of the material and moisture vapor is removed from the material into the drying medium. Heat is transported by convection from the surroundings to the particle surfaces and from there by conduction, further into the particle. Moisture is transported in the opposite direction as a liquid or vapor on the surface; it evaporates and passes on by convection to the surroundings.

Drying is generally evaluated experimentally by measuring the weight of a drying sample as a function of time. Drying curves may be represented in different ways; average moisture content versus time, drying rate versus time or drying rate versus average moisture content. Drying process can be described completely using an appropriate drying model, which is made up by differential equations of heat and mass transfer in the interior of the product and at its inter phase with the drying agent.

The review of literature on drying of guava revealed that limited work has been done on guava drying and there is a strong need to enhance the shelf life. Hence, the present study was undertaken with an objective, to study the drying characteristics of guava slices under three popular methods *viz.,* sun drying (SUN), shade drying (SHD) and hot air drying (HAD).

Material and Methods

Experimental Place

The experiment was conducted in the Laboratory of the Department of Post-Harvest Process and Food Engineering, College of Agricultural Engineering, JNKVV, Jabalpur (MP).

Preparation of Sample

Fresh guavas were procured from the local market at Jabalpur. Fresh and healthy guavas were selected and washed with tap water to remove the dust and dirt over the surface. The whole guava was cut into four pieces according to stem to calyx. The internal seed portion was removed and weighed into 500 g sample. The whole drying was performed in three replications and each replication contained three samples.

Drying Methods

Sun Drying

In sun drying perforated aluminium trays of 30x30 cm size were used to facilitate drying of guava slices in a single layer and placed 10 cms above the concrete floor on the roof of the laboratory building in direct sun light.

Shade Drying

In shade drying, slices of guava were spread over perforated trays and placed in the shade 10 cm above the concrete floor inside the laboratory hall.

Hot Air Drying

For hot air drying hot air oven (make Labtech Instrument, Indore (MP) was used. The operating range of hot air oven was 50 to 300 °C. The digital thermostat controlling system maintains the temperature. The drying was undertaken in the hot air oven at 50 °C temperature.

Test Parameters

The weight loss of guava slices at 30 min time interval was measured on the first day, 60 min on second day, 120 min on third day and 180 min on fourth day till the final weight after two consecutive time interval became constant.

Drying Characteristics

Moisture Content

The initial moisture content of guava was determined by standard AOAC 930.15 method. 2 g sample is placed in an aluminum dish which is in turn placed in an air oven set to 135 °C. The dish is removed after exactly two hours, covered and placed in a desiccator. After cooling the dish is weighed and the loss in weight

Experimental Design of Work

Treatments	No. of Replication								
	R_1			R_2			R_3		
	No. of Sample			No. of Sample			No. of Sample		
	S_1	S_2	S_3	S_1	S_2	S_3	S_1	S_2	S_3
Sun Drying	SUN_1	SUN_2	SUN_3	SUN_1	SUN_2	SUN_3	SUN_1	SUN_2	SUN_3
Shade Drying	SHD_1	SHD_2	SHD_3	SHD_1	SHD_2	SHD_3	SHD_1	SHD_2	SHD_3
Hot Air Drying	HAD_1	HAD_2	HAD_3	HAD_1	HAD_2	HAD_3	HAD_1	HAD_2	HAD_3

is H_2O. The dry basis (%) moisture content was calculated as follows (Upadhyay *et al.,* 2008) :

$$MC_{db}(\%) = \frac{Ww}{Wd} \times 100 = \frac{m}{100 - m} \times 100$$

And on wet basis (%) moisture content was calculated as (Rodrigues & Fernandes, 2007) :

$$MC_{wb}(\%) = \frac{Ww}{Ww + Wd} \times 100$$

The following relationship between dry and wet basis moisture content were suggested by (Ekechukwu, 1999).

$$MC_{db}(\%) = \frac{MCwb}{100 - MCwb} \times 100$$

Where,

W_d = weight of dry matter (g)

W_w = weight of water (g)

MC_{db} = moisture content dry basis (%)

MC_{wb} = moisture content wet basis (%)

Moisture Ratio (MR)

Moisture ratio is the ratio of the moisture content at any given time to the initial moisture content (both relative to the equilibrium moisture content). It can be calculated as (Ozbek & Dadali, 2007):

$$MR = \frac{M - Me}{Mo - Me}$$

Where,

M = instantaneous moisture content (% db)

M_o = initial moisture content (% db)

M_e = equilibrium moisture content (EMC) of material (% db)

Drying Rate

Drying rate (g of water per minute per 100 g of bone dry material) were calculated (Chakraverty, 2005) as following:

$$\text{Drying rate} = \frac{\text{Amount of Moisture removed (g)}}{\text{Time taken (min) x (Total Bone dry weight of sample in g/100g)}}$$

Similarly, the drying rate will be approximately proportional to the difference in moisture content between the product being dried and EMC at the drying air state (Ozbek & Dadali, 2007):

$$DR = \frac{Mt + dt - Mt}{dt}$$

Where,

DR = drying rate (g/g min)

M_t = moisture content at time t (%db)

M_{t+dt} = moisture content at time t+dt (%db)

d_t = time of successive measurements (min)

Determination of Drying Rate Constant

Drying rate constant is a function of drying air temperature. One of the most basic models used to describe moisture loss during the drying process is a simple exponential model (Sun and Woods, 1994):

$$MR = \frac{M - Me}{Mo - Me} = A \exp(-kt)$$

Where MR is the moisture ratio; M is the moisture content (% db) at any given time during drying; M_0 is the initial moisture content; Me is the equilibrium moisture content; *k* is the drying constant (min^{-1}); and *t* is time in min. The exponential model was linearized to form of straight line equation (Y = mx + c) which is as follows.

$$\ln(MR) = \ln(A) + (-Kt)$$

Thus when experimental data are plotted in the form of equation 3.18 k can be determined graphically by drawing a straight line and determining slope of straight line.

Results and Discussion

Initial Moisture Content of Guava

The initial moisture content in all the samples of guava was measured as 83.17 per cent (wb) or 494.18 per cent (db).

Drying Characteristics of Guava

In the experiment three different drying methods adopted were sun drying (SUN), shade drying (SHD) and hot air drying (HAD). For recommendation of the best drying technique the three methods mentioned above were considered. The guava was dried continuously in batches of 500 g as a three replication and each replication contained three samples. The reduction in weight was noted at six different time interval of (30, 60, 90, 120, 180 and 360 minutes) till the constant weight was achieved. The average temperature was determined 26 ^{0}C in SUN drying and 22 ^{0}C in SHD drying. In case of HAD the temperature was fixed at 50 ^{0}C.

Drying Curve Assessment- Moisture Ratio versus Drying Time

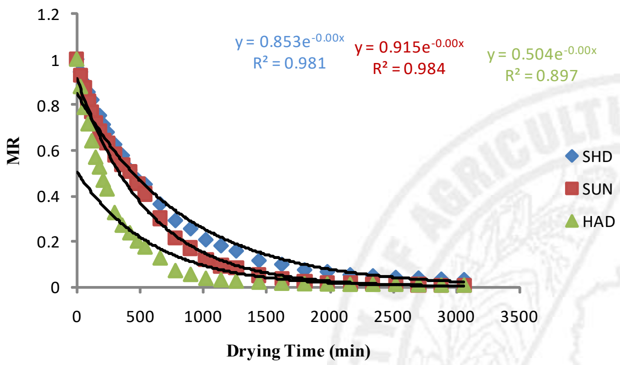

Fig. 1: Drying curve (MR versus drying time) of guava slices under different drying methods

Fig.1 depicts the typical characteristics drying curves of moisture ratio (MR) versus drying time (t) for fresh guava slices under SUN, SHD and HAD. The results showed that drying time decreased greatly as drying temperature increased. The drying curves typically demonstrated smooth diffusion-controlled behaviour under all drying conditions. In general, the time required to reduce the moisture ratio to any given level was dependent on drying condition, being the longest in SHD and shortest at HAD. The drying curve of SUN and SHD drying were good fitted to exponential equation.

Drying Rate Versus MC (% db)

Drying rate curves are presented in Fig. 2, Fig. 3 & Fig. 4, which shows the effects of drying air temperature on the drying rate of slices of guava.

This figure also shows that the drying rate falls linearly as the moisture content is decreased in the drying process. In addition, higher the drying air temperature, greater is the drying rate.

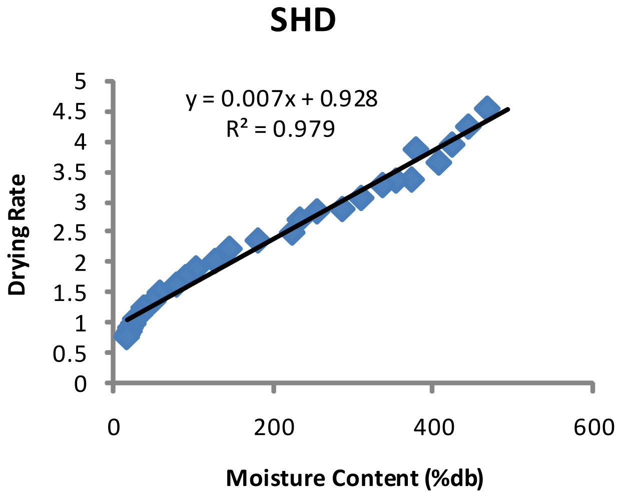

Fig. 2: Drying rate curve of guava slices under shade drying

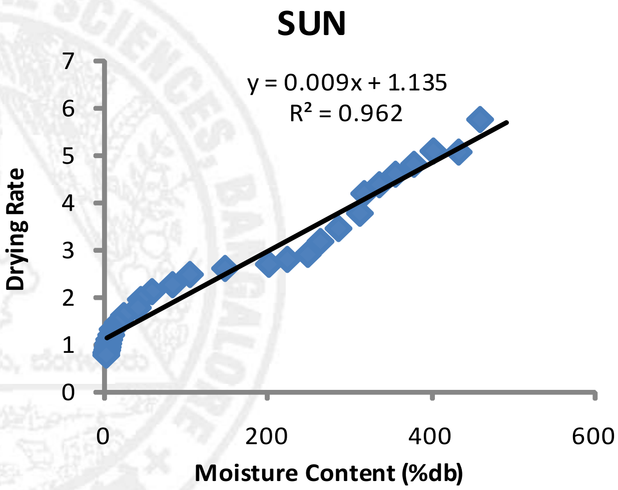

Fig. 3: Drying rate curve of guava slices under sun drying

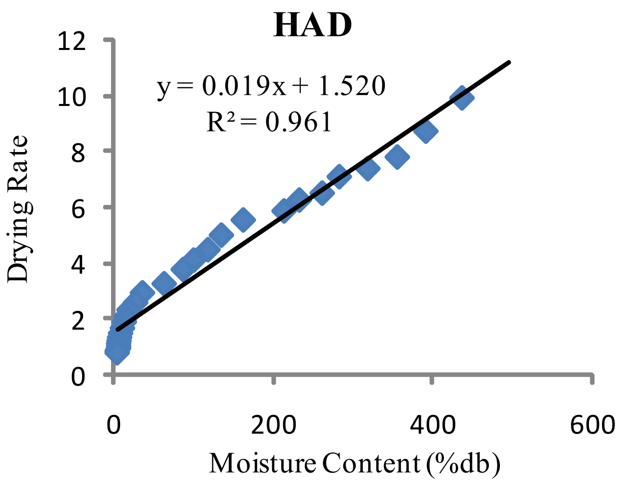

Fig. 4: Drying rate curve of guava slices under hot air drying

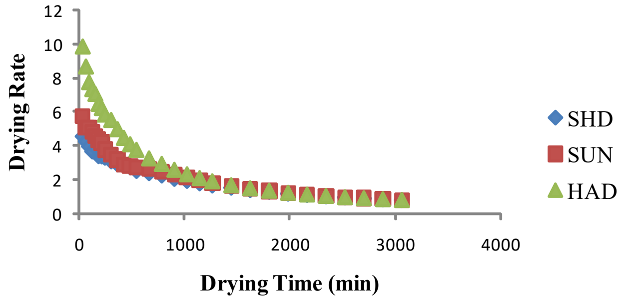

Fig. 5: Drying rate curve (Drying rate versus drying time) of guava slices under different drying methods

Moisture Content (% db) Versus Time

The curves between MC (% db) versus drying time are shown in Fig. 6. It is observed that moisture content of samples decreases exponentially with the drying time. It was observed that lowest MC (db) was observed in HAD experiment as compared to others. This may be due to high temperature of air which reduces the Rh of drying air and promotes the moisture removal rate. Highest level of MC (db) was observed in SHD drying method. This may be due to the lower temperature of atmosphere during drying experiment.

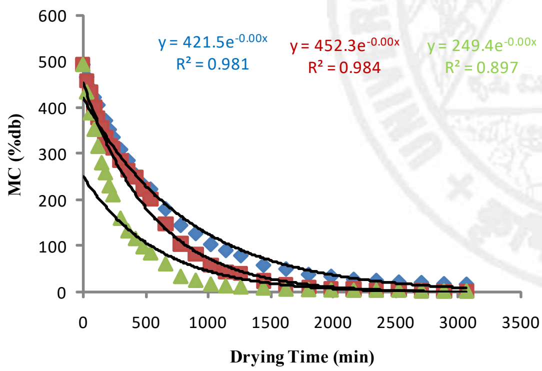

Fig. 6: Moisture depletion pattern of guava slices under different drying methods

Determination of Drying Constant

From the result obtained and interferences drawn, it is concluded that, the time required to reduce the moisture ratio to any given level was dependent on drying condition, being the longest in SHD and shortest at HAD. The drying curve of SUN and SHD drying were good fitted to exponential equation. The drying rate falls linearly as the moisture content is decreased in all the drying process. Moisture content of samples

TABLE 1

The drying rate constant of different drying methods of guava slices

Drying Methods	Drying rate constant
Sun Drying	0.0018
Shade Drying	0.0012
Hot Air Drying	0.0017

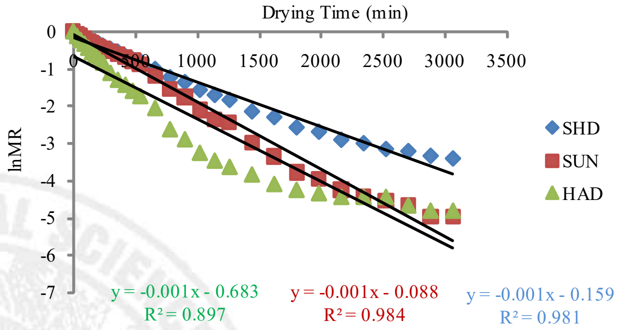

Fig. 7: Determination of drying rate constant

Note : SHD - Shade drying; SUN - Sun drying & HAD - Hot air oven drying

decreases exponentially with the drying time. The average temperature was determined 26 ^{0}C in SUN and 22 ^{0}C in SHD. In case of HAD the temperature was fixed at 50 ^{0}C. The colour of guava slices became yellowish with an increase in temperature. We found SHD drying as the best method for the dehydration of guava in terms of natural colour preservation.

REFERENCES

AOAC, 2005, Official Methods of Analysis. 18th edn. Association of Official Analytical Chemists; Arlington, VA, USA.

CHAKRAVERTY, A., 2005, Post Harvest Technology of cereals, Pulses and oilseeds, 3rd Edition, oxford and IBH Publishing Co. Pvt. Ltd., New Delhi, 54 - 55.

EKECHUKWU, O. V., 1999, Review of solar-energy drying systems I: an overview of drying principles and theory. *Energ. Convers. Manage.*, **40** (6) : 593 - 613.

GANDHI, N. AND SINGH, B., 2014. Study of extrusion behaviour and porridge making characteristics of wheat and guava blends. *J. Food Sci. Technol.*, **52**. 10.1007/s13197-014-1302-1.

KUMARI, P., MANKAR, A., KARUNA, K., HOMA, F., MEIRAMKULOVA, K. AND SIDDIQUI, M. W., 2020, Mineral composition, pigments and postharvest quality of guava cultivars commercially grown in India. *Journal of Agriculture and Food Research, Vol. 2* (https://doi.org/10.1016/j.jafr.2020.100061).

LIMA, R. S., FERREIRA, S. R. S., VITALI, L. AND BLOCK, J. M., 2019, May the superfruit red guava and its processing waste be a potential ingredient in functional foods? *Food Res. Int.*, **115**, 451 - 459.

OZBEK, B. AND DADALI, G., 2007, Thin-layer drying characteristics and modelling of mint leaves undergoing microwave treatment. *J. Food Eng.*, **83** (4) : 541 - 549.

RIBEIRO, L., LEONEL, S., SOUZA, J., GARCIA, E., LEONEL, M., HONORATO MONTEIRO, L., SILVA, M. AND BIBIANO FERREIRA, R., 2020, Improving the nutritional value and extending shelf life of red guava by adding calcium chloride. *LWT-Food Sci. Technol.*, **130**. 109655. 10.1016/j.lwt.2020.109655.

RODRIGUES, S. AND FERNANDES, F. A. N., 2007, Dehydration of melons in a ternary system followed by air-drying. *J. Food Eng.*, **80** (2) : 678 - 687.

SHIGIHALLI, S. AND VIJAYALAKSHMI, K. G., 2018, Effect of pretreatments on dehydration of Ivy Gourd. *Mysore J. Agric. Sci.*, **52** (3) : 547 - 552.

SUN, D. AND WOODS, J. L., 1994, Low-Temperature Moisture Transfer Characteristics of Barley: Thin-Layer Models and Equilibrium Isotherms. *J. Agric. Engg. Res.*, **59** (4) : 273 - 283.

UPADHYAY, A., SHARMA, H. K. AND SARKAR, B. C., 2008, Characterization and dehydration kinetics of carrot pomace, *Agricultural Engineering Inter national: The CIGR E journal.* Manuscript FP 07 35 (10) : 31 - 35.

(*Received :* November 2020 *Accepted :* January 2021)