Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(6): 1998-2004
Received: 16-09-2019
Accepted: 20-10-2019

Priti P Lad
Assistant Professor, Department of Agriculture Process Engineering, College of Agriculture Engineering and Technology, Saralgaon, Maharashtra, India

Nitesh A Pachpor
Assistant Professor, Department of Renewable Energy Technology, College of Agriculture Engineering and Technology, Saralgaon, Maharashtra, India

Reshma D Ghutukade
Student, CAET Saralgaon, College of Agriculture Engineering and Technology, Saralgaon, Maharashtra, India

Shital D Bhagat
Assistant Professor, Department of Renewable Energy Technology, College of Agriculture Engineering and Technology, Saralgaon, Maharashtra, India

Corresponding Author:
Priti P Lad
Assistant Professor, Department of Agriculture Process Engineering, College of Agriculture Engineering and Technology, Saralgaon, Maharashtra, India

Analysis of drying characteristics of ginger by different drying methods

Priti P Lad, Nitesh A Pachpor, Reshma D Ghutukade and Shital D Bhagat

Abstract
Preservation of foodstuffs through drying is a very ancient practice. Processing of commercial value spice crops such as ginger command priority in many countries including India as it is considered as a major food ingredient on account of its natural flavour and medicinal properties. This study was undertaken to identity suitable drying conditions by using different artificial drying methods. Drying assays were conducted in Open sun drying, Indirect solar cabinet dryer, Tray dryer and Hot air oven for the ginger flakes at temperature ranges of 50, 60, 70 and 80 °C. The pre-treated flakes with an initial moisture content of 525.2 per cent (db) were dried to 7 to 12 per cent moisture content (db) and the moisture changes during drying were monitored. These artificial drying methods were compared with sun drying. Drying duration and maximum drying rate constituted comparative criterion for the process. It was found that Open sun drying took more time (19 Hrs) as compared to Indirect solar cabinet drying (16 Hrs), Tray drying (9 Hrs) and Hot air oven (11Hrs) for the same level of initial and final moisture content conditions. The highest temperature recorded was for the tray dryer (50 °C) followed by indirect solar cabinet dryer (61 °C), open sun drying (51 °C). The drying characteristics are nearly similar for all the methods with a little variation. Drying rates were affected by drying air temperature and exhibited only falling rate period. Compare the Open sun drying, Indirect solar cabinet dryer, Tray Dryer and Hot air oven by drying ginger. Readings of moisture content taken at intervals of 15 min for first 2 h, 30 min for next 2 h and hourly for rest of drying period. Drying was continued till the sample attained a constant weight.

Keywords: Open sun drying, indirect solar cabinet dryer, tray dryer and hot air oven

1. Introduction
Drying is a complicated process involving simultaneous heat and mass transfer. The required amount of energy to dry a particular product depends on many factors, such as initial moisture content, final moisture content, drying air temperature, relative humidity and velocity. Various mathematical models describing the drying behavior of different food materials have been proposed to optimize the drying process and design efficient dryers.

Open air and uncontrolled sun drying is still the most common method used to preserve and process Agricultural product. But uncontrolled drying suffers from serious problem of wind born dust, infestation by insect, product may be seriously degraded to the extent that sometimes become market valueless and resultant loss of and have to the food quality may have adverse economic effects on domestic and international market. Dryers have been developed and used to dry agricultural products in order to improve shelf life. Because of full scale experimentation of different products and configurations of drying system is very time consuming and costly. In order to improve the quality, the traditional natural sun drying must be replaced by modern drying methods. Drying characteristics of specific products should be determined to improve the quality.

Solar dryers are available in a range of size and design and are used for drying of various agricultural products. Various types of Dryers are available in the market as per requirement of farmers. Primarily all the drying systems are classified on the basis of their operating temperature ranges that is High Temperature solar dryer and Low Temperature Solar dryer.

Ginger (*Zingiber officinale*) is an important commercial crop grown for its aromatics rhizomes which are used both, as spice and medicine. The word Zingiber comes from the ancient Sanskari name ‘Singabera meaning horn-shaped which gave rise to greek Zingiberi and later latin Zingiber. Ginger was known and esteemed by ancient Greeks and Roamans, who obtained the spice from Arabian Traders via Red Sea who kept a secret of ginger purchased by them from Indian source. It first appeared in the writings of Confucius in 5th century BC and it is medicinally used in the West for at least 2000 years. It was introduced to Germany and France in nineteenth century and England in tenth century. It was first oriental spice known in Europe having been obtained by Greeks and Romans from the Arab traders.

Aphrodisiac properties of the spice have been described in "Thousands and One Night". Europe imported preserved ginger from China as a sweet meat as early as middle ages. Arab took it from India to east Africa in 13th century.

It was brought to Mediterranean region from India by traders during 1st century AD Spaniard Francisco de Mendoza introduced the crop in Mexico soon after discovering the country. Spaniards also took it to Jamaica. The best quality of ginger is produce in Jamaica and India followed by West Africa. Chinese ginger has low pungency and aroma and hence cannot be used for distillation. Japanese ginger lacks characteristics ginger aroma.

It is a valuable cash crop and plays an important role in Indian Ayurvedic medicine as a folk remedy to promote cleaning of the body through perspiration, to calm nausea and to stimulate the apprtite. Ginger tea is also used as a carminative and in the symptomatic treatment of colds. Ginger contains gingerol, an oleoresin (Com bination of volatile oils and resin) that accounts for the characteristics aroma and therapeutic properties. Components of gingerol (Zingiberone, bisabolene, cam phene, geranial, linalool and borneol) possess beneficial properties for the treatment of poor digestion, heartburn, vomiting and preventing motion sickness.

2. Methods and Material

2.1 Materials

The experiment was conducted at College of Agriculture Engineering and technology Saralagoan. The local variety of fresh Ginger was purchased from the Saralgaon market and was used in the experiments. In the present experiment Ginger were used for drying. After purchasing, the sorting process was carried out manually to remove all the undesirable material. Then the material was washed thoroughly in running water to remove the adhering soil and extraneous matter and surface dried with filter paper. The cleaned product was then weighed and 100 g samples were made for each methods of drying. Initial moisture content of the Ginger was determined by oven drying method at 70 ^{o}C $\pm$ 2 ^{o}C till constant weight occurred.

2.2 Drying equipments

Solar energy is used for drying various industrial and agricultural products in open sun and in solar dryer. In hot sunny areas where the solar radiation is abundant, solar drying seems to be the most promising and modest approach for preservation of various agricultural products. In the present study, an attempt was made to compare the drying characteristics of the Ginger using different drying method The Ginger were dried using four methods viz.; open sun drying, tray drying, solar indirect cabinet drying and hot air oven drying at a temperature of 70 ^{o}C.

- **Open sun drying**

Sun drying is used to denote the exposure of the food material to direct solar radiation and the convective power of the wind. Black polyethylene sheets are mostly used as drying platform because it absorbs most of the solar radiations. To create the sun drying experiments, a black polyethylene sheet was selected to better absorption of solar radiations. The surface area of the sheet was enough large to spread 100 g of ginger. Black polyethylene sheets were completely cleaned and the samples were spread over the sheets uniformly. The loss of moisture was recorded at every 15 min for first two-hour interval, at every 30 minutes for next two-hour interval and at every one hour for rest of drying period, by means of an electronic balance (accuracy 0.001 g, capacity 3000 g) shown in Plate 3.2. Surface temperature was also measured periodically with the help a of thermometer mercury in glass bulb. Also relative humidity was noted by means of hygrometer. Drying was continued till the sample attained a constant weight. The drying time and drying rate depended on the ambient temperature.

- **Indirect solar drying**

An indirect solar cabinet dryer developed at College of Agriculture Engineering and Technology, Saralgaon, thane was also used for drying of Ginger. It consists of a transparent glass fixed to transmit the solar radiations and three trays for loading the product the cabinet of the dryer made up of GI sheet with thermocol insulation and fitted an angle iron frame. The front portion fitted with glass is tilted at an angle of 45^{o} to facilitate maximum exposure to the solar radiation. The Indirect solar tray dryer is shown in fig.

The sample of Ginger was put in a single layer on the trays (100 g). The loss of moisture was recorded at every 15 min for first two-hour interval, at every 30 min for next two-hour interval and at every one hour for rest of drying period. The entire process of opening the door, withdrawing and weighing the sample and closing the door took not more than one minute. The drying was performed continuously for 16 h. The weight of sample was taken on a precise electronic balance having least count 0.001 g. The dried sample was collected from trays, cooled to room temperature, sealed in Ziploc (Self sealing) polyethylene bags, and kept in ambient conditions.

Fig 2.1: Solar dryer

- **Tray dryer**

Mechanical drying of ginger was done using electrical tray dryer (Fig. 3.4) employing hot air stream at constant temperature. The inlet air was heated using 6 electric heat rods, each having 1kW heat load, equipped inside the dryer. The dryer has one inlet for the air to get inside the dryer and then air was heated with the heating rods and there is one outlet for the moist hot air and this outlet can be opened or closed with the help of a lever. The dryer had a motor of 0.25 hp Selection and procurement of raw material 20 equipped outside the dryer. The desired temperature was obtained by selecting the required readings on the digital temperature indicator and keeping the dryer running for about half an hour before starting drying of the product.

Fig 2.2: Tray Dryer

Method of analysis

The analysis of different properties of dried gingers was done to deduce valuable information on mechanism of drying of ginger. Statistical analysis of drying process was made to know the relative effect of various drying conditions on the final moisture content of ginger.

1. **The moisture removing rate was expressed on a dry basis**

Moisture removing rate on % dry basis can be calculated using Eq. (1):

$$M.C\ (dry\ basis) = \frac{Ww-Wd}{Wd} \times 100 \quad \text{---- (1)}$$

Where,
M.C (dry basis) is the initial moisture removing rate (%, dry basis),
W_w is the weight of wet ginger (g), and
W_d is the weight of dry ginger (g).

2. The moisture removing rate was expressed on a wet basis

Moisture removing rate on % wet basis can be calculated using Equ

$$M.C\ (wet\ basis) = \frac{Ww - Wd}{Ww} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where,
M.C (wet basis) is the initial moisture removing rate (%wet basis),
W_w is the weight of wet ginger (g), and W_d is the weight of dry ginger (g).

2. **The moisture ratio of ginger during the drying can be obtained using Eqn**

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

Where,
M is the moisture content at any drying time (%, dry basis), Mo is the initial moisture content (%, dry basis), and Me is the equilibrium moisture content (%, dry basis).

4. Determination of drying rate

Drying rate of the ginger slices at any time was calculated by the following formula Eq. (3):

$$R = \frac{Wr}{T \times Wd \times 100}$$

Where,
R = Drying rate (min-1),
Wr = Amount of moisture removed (g),
T = Time of drying (min), and
Wd = Total bone dry weight of sample (g).

3. Results and Discussion

The results of the experiments for determining drying characteristics of Fresh Ginger are presented and discussed in this chapter. Experimental data have been analyzed, presented and interpreted logically in the light of the theories.

- **Temperature and relative humidity of drying air in different drying methods**

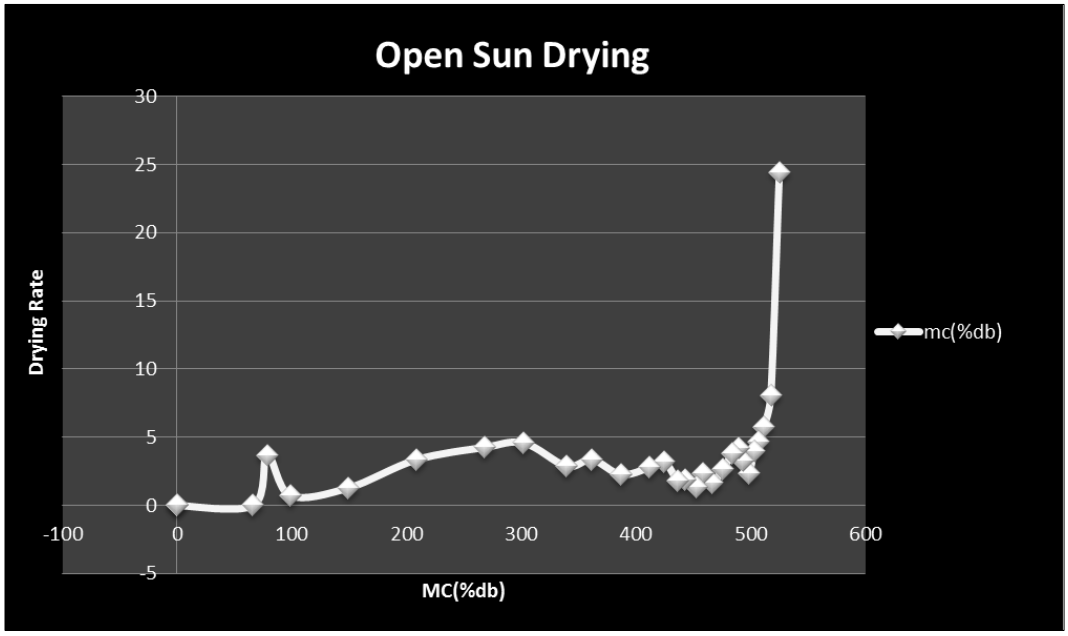
The present study was conducted in Oct. months of 2019. Fig 4.1 shows the variations of surface temperature and relative humidity (RH) of the ambient air with respect to time during the drying of Ginger. The surface temperature and relative humidity of prevailing ambient air were observed to vary from 40°C to 50°C and 45 to 55%, respectively during drying of Ginger. The RH of ambient air decreased with the increase in surface temperature. In all the drying methods, the maximum temperature was achieved at between 12 to 2.00 pm. The temperature of ambient air was varying throughout the drying time, the temperature of ambient air increased gradually up to 2.00 o'clock and its maximum value was recorded during 12 to 2.00 PM, thereafter the temperature was found to decrease gradually.

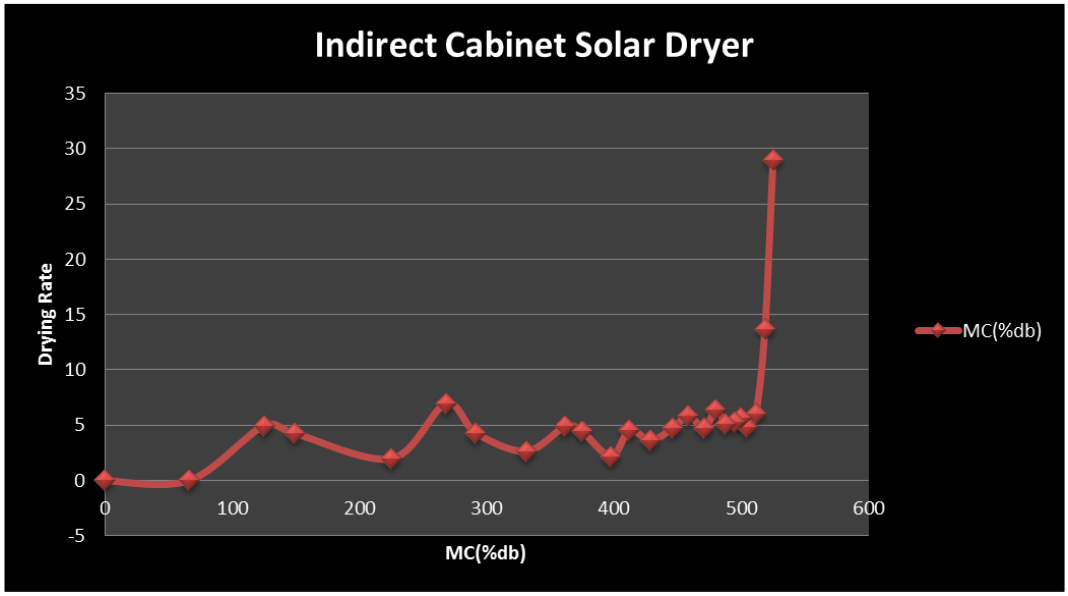
- **The drying characteristics of ginger**

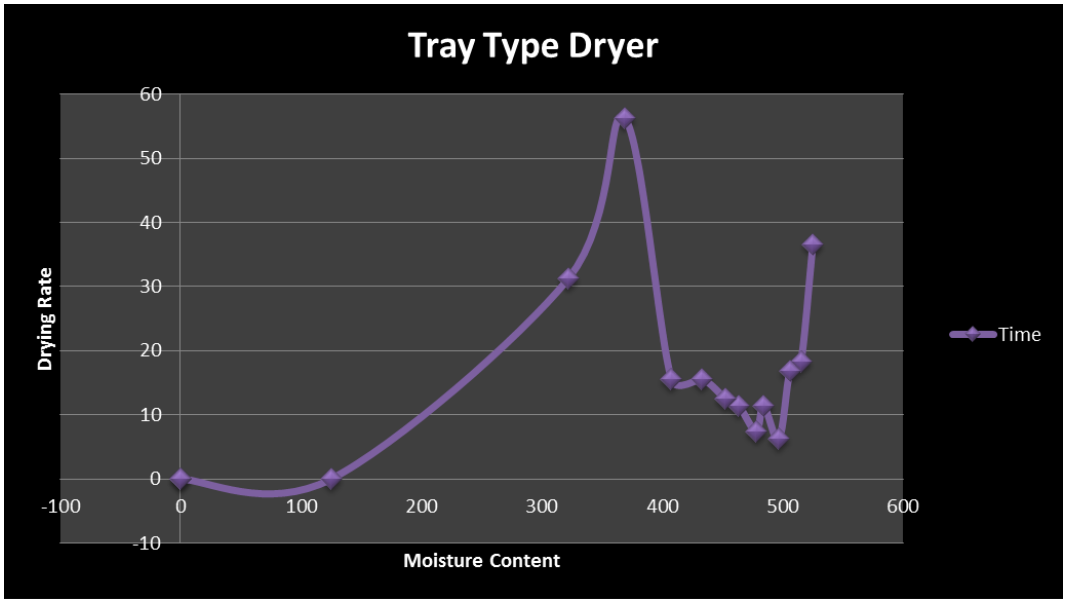
The Ginger were dried using four methods *viz*., open sun drying, Tray drying, solar indirect cabinet drying and oven drying at a temperature of 70°C. The initial average moisture contents of Ginger were found to be 525 (% db), respectively. The observations of drying experiment are given in Appendices. The drying characteristics of Ginger under different drying methods are summarized below. The moisture content shown in different graphs is the average of three replications.

- **Variation in moisture content of ginger with respect to drying rate**

The drying behavior of Ginger in different drying methods is presented in Fig 4.2 and 4.3, as a plot of moisture content *versus* time of exposure. It can be seen that typical drying curves have been obtained for Ginger. The maximum drying temperature was achieved during the period of 12 to 2.00 PM for the dryers whereas as the hot air oven was set at 70 °C throughout the drying period. The highest temperature recorded was for the tray dryer (50 °C) followed by indirect solar cabinet dryer (61 °C), open sun drying (51 °C). The drying characteristics are nearly similar for all the methods with a little variation.


Open Sun Drying
Drying Rate
MC(%db)
mc(%db)
30
25
20
15
10
5
0
-5
-100
0
100
200
300
400
500
600


Indirect Cabinet Solar Dryer
Drying Rate
MC(%db)
MC(%db)
35
30
25
20
15
10
5
0
-5
0
100
200
300
400
500
600


Tray Type Dryer
Drying Rate
Moisture Content
Time
60
50
40
30
20
10
0
-10
-100
0
100
200
300
400
500
600

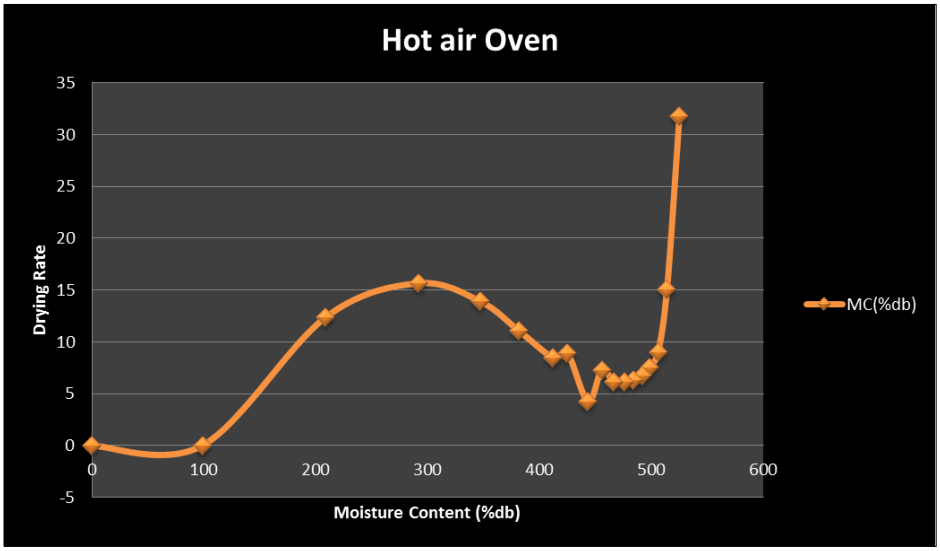
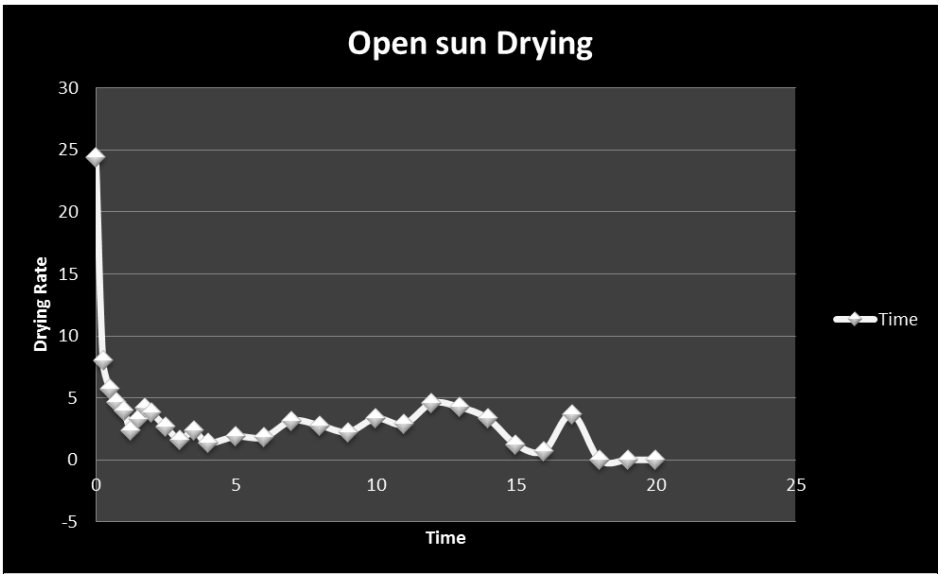
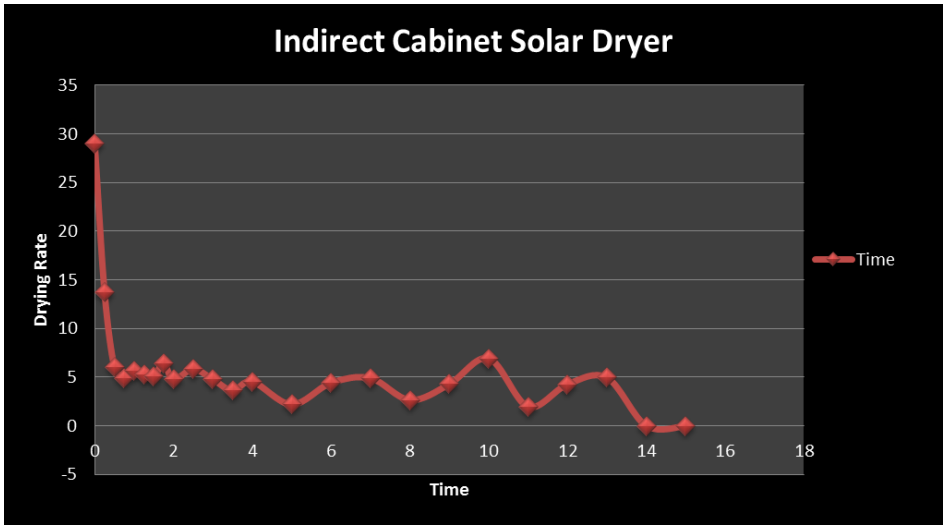


Fig 4.1: Variation of moisture content MC (% db) ginger with drying rate by different drying method

- **Variation of drying rate of Ginger with respect to time**

The drying characteristics of the Ginger were also evaluated on the basis of drying rate in different methods. The changes of drying rate with drying time under different drying methods are shown in Fig.4.2 On examination of the plots between drying rate and drying time, it is clear that the entire drying process was accomplished in the falling rate period of drying and the constant rate period was absent like many other biological materials. This indicates that there was no free water on the product surface. Further, it can be seen that as the drying time increased the drying rate decreased.





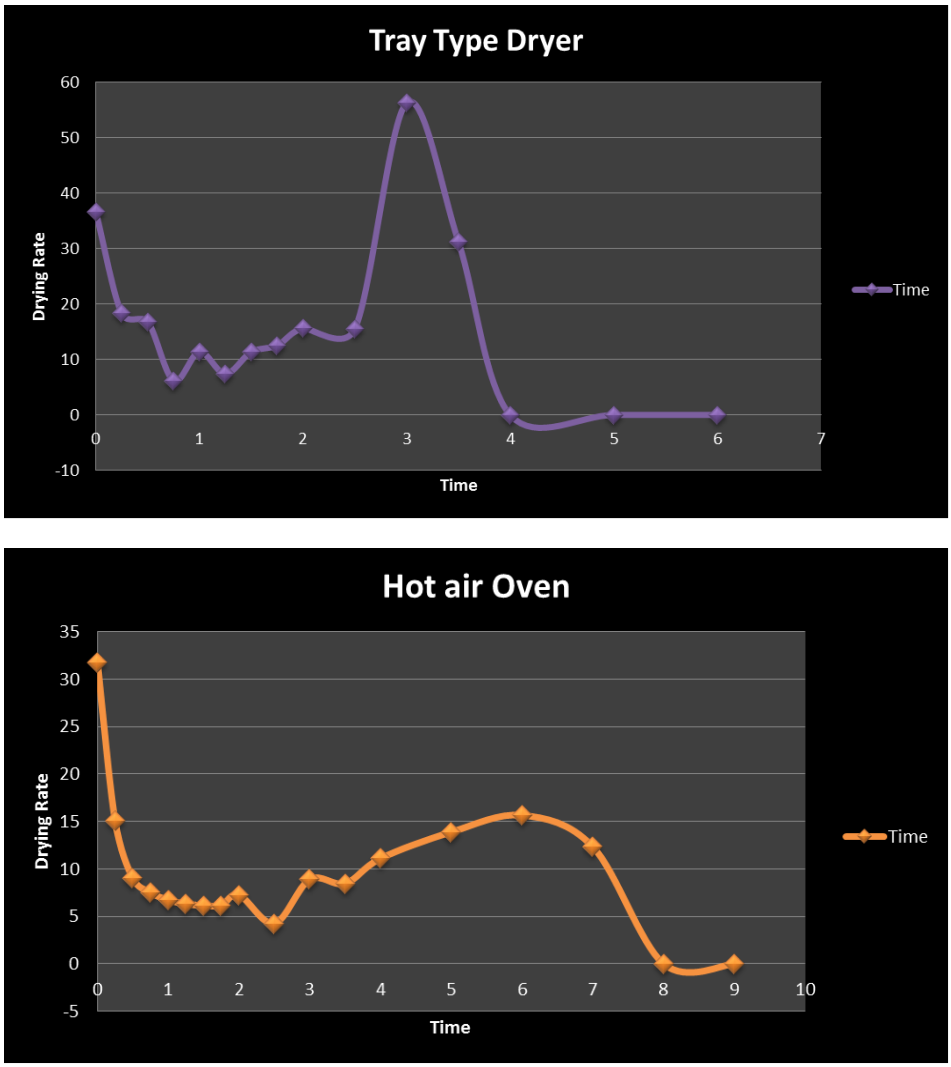


Fig 4.2: Variation drying rate of ginger with time by different drying method

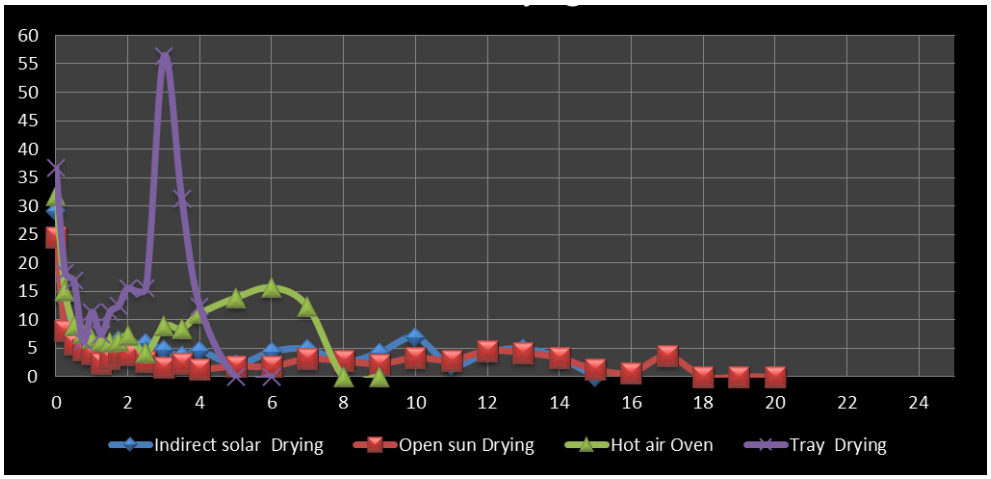


Fig 4.3: Variation of drying rate with drying time for ginger under different drying methods

4. Summery and Conclusion

Experiments were conducted to study the drying characteristics of ginger slices, by evaluating the changes in moisture ratio and drying rate with drying time of dehydrated ginger slices during tray drying at temperature (50 ^{0}C) and loading densities (100g/m^{2}).

From the above studies the following results were obtained:

- Open sun drying took nearly 20 h to dry red ginger from an initial moisture content of 525 per cent (db).
- The time taken under indirect solar cabinet drying was about 16 h ginger. The final moisture content of product was 7 per cent (db) for Ginger, respectively.

- Tray dryer took 8 h for ginger, respectively. The moisture content of final dried product was 4 per cent (db) for fresh ginger.
- Hot air oven took minimum time to dry. In 10 h of drying span the ginger up to 3 per cent (db) moisture content.
- Ginger dried in open sun found to have maximum moisture content *i.e.* 9 per cent (db) for Ginger.

5. References

1. Adolfina, Koroch, Lalasoa Ranarivelo, Olivier Behra, Rodolfo Juliani H, James Simon E. Quality attributes of ginger and cinnamon essential oils from Madagascar, Journal of the Essential oils. 2007; 5(19):541-543.
2. Ahmed Abed Gatea. Design and construction of a solar drying system, a cylindrical section and analysis of the performance of the thermal drying system, Department of Agricultural Mechanization, College of Agriculture, University of Baghdad, Iraq, 2010.
3. Diemuodeke E, Ogheeneruona Momoh OL. YUSUF Design and Fabrication of a Direct Natural Convection Solar Dryer for Tapioca; Department of Mechanical Engineering, University of Port Harcourt Department of Civil and Environmental Engineering, University of Port Harcourt, P.M.B. 5323, Choba, Rivers State, Nigeria; Leonardo Electronic Journal of Practices and Technologies ISSN 1583-1078. 2011; 18:95-104.
4. Eleazu CO, Amadi CO, Iwo GA. Biochemical qualities of 10 elite accessions of ginger (*Zingiber officinale* Roscoe). African Journal of Food Science & Technology. 2012; 3(18):187-192.
5. Gunasekaran S. Pulsed microwave - vacuum drying of food materials. Drying Technol. 1999; 17(3):395-412.
6. Hawaldar MNA, Uddin MS, Ho C, Teng ABW. Drying characteristics of tomatoes, Journal of food engineering. 1991; 14:259-268.
7. Hasibuan Hariyanto R, Alexander Ashari M, Ridha Herbal Dryer. drying of ginger (*Zingiber officinale*) using tray dryer, 2018.
8. Hossaina MA, Bala BK. Drying of hot chili using solar tunnel drier ; Farm Machinery and Postharvest Process Engineering Division, Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh. Department of Farm Power and Machinery, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh, 2006.
9. Gowda SJ, Gupta CP, Ojha TP. Studies on dehydration of ginger. Journal of Agricultural Science. 1986; 20:186-194.
10. Kumar Ashok, Kulakarani Neha, Mehta Birendrakumar. Drying kinetics of ginger (*Zingiber officinal*) slices undergoing microwave drying. Mukundjee pandey S.K Acharya, Ipsita Mishra Drying of chili using Solar cabinet Dryer & Analysis with Result of Various Parameters, 2015.
11. Mukundjee Pandey, Acharya SK, Ipsita Mishra. Drying of chili using Solar cabinet Dryer & Analysis with Result of Various Parameters. 2015.
12. Jayashree E, Visvanathan R. Physical biochemical parameters of Fresh and dry ginger, Journal of Spices and Aromatic Crops. 2011; 20(1):14-21.
13. Karhale G, Kalamse V, Pawar N, Kalamse G. Dielectric study of ginger (*Zingiber officinal*e) at 9.85 GHZ frequency, International Journal of Physics and Mathematical Sciences. 2012; 2(4):52-59.
14. Malu SP, Obochi GO, Tawo EN, Nyong BE. Antibacterial activity and medicinal properties of ginger (*Zingiber officinale*), Global journal of pure and applied sciences. 2008; 15(3):365-368.
15. Ravinder Kumar Sahdev. Open sun and Greenhouse, Drying of Agricultural and Food product, 2014.
16. Singh B, Kumar BL. Dehydration of ginger varieties Indian Food Packer, 1984, 64-67.
17. Ratnambal MJ, Gopalam A, Nair MK. Quality Evaluation in Ginger (*Zingiber officinale* Rose.) in Relation To Maturity, Journal of plantation Crops. 1987; 15(2):108-117.
18. Singh B, Kumar BL. Dehydration of ginger varieties Indian Food Packer, 1984, 64-67.
19. Sansaniwal SK, Kumar M. Analysis of ginger drying inside a natural convention indirect solar dryer: An experimental study, 2015.
20. Singh B, Kumar BL. Dehydration of ginger varieties Indian Food Packer, 1984, 64-67.
21. A Waheed Deshmukh Mahesh N. Varma Chang kyooyoo and Kailas I Wasewar Investigation of solar drying of ginger (*Zingiber officinale*) Empirical Modeling, Drying characteristics, and aulity study, 2013).
22. Tang J, Ran X. Temperature and moisture change during micro wave drying sliced food. Drying Technol. 1999; 17(3):413-432.
23. Zhannan Yang, Weiping Yang, Quancai Peng, Qiansong He, Yong Feng, Shiqiong Luo *et al*. Volatile phytochemical composition of rhizome of ginger after extraction by headspace solid-phase micro extraction, petroleum ether extraction and steam distillation extraction. A Journal of the Bangladesh Pharmacological Society (BDPS). 2009; 4:136-143.