International Journal of Academic Research and Development
ISSN: 2455-4197
Impact Factor: RJIF 5.22
www.academicsjournal.com
Volume 3; Issue 2; March 2018; Page No. 949-954

Study on drying characteristics of vegetables

P Ramya[1], V Bhasker[2], D Saraswathi[3], K Santhosh[4], G mounika[5], Srinivasa Maloo[6]
[1, 3-5] M. Tech Food Processing Technology, University College of Technology, Osmania University, Telangana, India
[2] Assistant Professor, College of Technology, University College of Technology, Osmania University, Telangana, India
[6] Associate Professor, College of Technology, University College of Technology, Osmania University, Telangana, India

Abstract
The purpose of this study is investigate the drying characteristics of the vegetables (Spinach, Tomato and Capsicum). The drying characteristic and time required for drying of were studied and final dry weight of the vegetables were estimated. In this study the drying characteristics i.e the amount of moisture removed for every 10min by try dryer at 70℃ and every 1h by hot air dryer is calculated at 105℃ temperatures for the respective samples and also drying rates were estimated using Infrared and Sun drying. From the above study on dehydration of vegetables were found to give better results depending upon the Optimizing Conditions for maintaining better quality, appearance, color and texture.

Keywords: tomato and capsicum, spinach, color and texture

1. Introduction
Drying is one of the oldest methods of food preservation. Drying preserves foods by removing enough moisture from the food to prevent decay and spoilage. The moisture content of chillies at the harvest time is 70-80% (wb) and is very susceptible to insect and fungal attack during storage. Excessive delay in the drying results in growth of micro flora and subsequent loss of quality or total storage (Singh *et al*., 1982).
Drying is defined as the process of moisture removal due to simultaneous heat and mass transfer. Moreover it's one of the oldest methods of food preservation (Gupta *et al.*, 2002) [11, 12] Drying removes the moisture from the food so bacteria, yeast and mold cannot grow and spoil the food. Drying also slows down the action of enzymes (naturally occurring substances which cause foods to ripen), but does not inactivate them.
Because drying removes moisture, the food becomes smaller and lighter in weight. When the food is ready for use, the water is added back, and the food returns to its original shape. Foods can be dried in the sun, in an oven or in a food dehydrator by using the right combination of warm temperatures, low humidity and air current. In drying, warm temperatures cause the moisture to evaporate. Low humidity allows moisture to move quickly from the food to the air. Air current speeds up drying by moving the surrounding moist air away from the food.

1.1 Sun Drying
The high sugar and acid content of fruits make them safe to dry in the sun. Vegetables and meats are not recommended for sun drying. Vegetables are low in sugar and acid. This increases the risks for food spoilage. Meats are high in protein making them ideal for microbial growth. when heat and humidity cannot be controlled. To dry in the sun, hot, dry, breezy days are best. A minimum temperature of 86°F is needed with higher temperatures being better. It takes several days to dry foods out-of-doors. Because the weather is uncontrollable, sun drying can be risky. Also, the high humidity in the South is a problem. A humidity below 60 percent is best for sun drying. Often these ideal conditions are not available when fruit ripens. Fruits dried in the sun are placed on trays made of screen or wooden dowels. Screens need to be safe for contact with food. The best screens are stainless steel, teflon coated fiberglass or plastic. Avoid screens made from "hardware cloth." This is galvanized metal cloth that is coated with cadmium or zinc. These materials can oxidize, leaving harmful residues on the food. Also avoid copper and aluminum screening. Copper destroys vitamin C and increases oxidation. Aluminum tends to discolor and corrode.

1.2 Hot air oven drying
Everyone who has an oven has a dehydrator. By combining the factors of heat, low humidity and air flow, an oven can be used as a dehydrator. An oven is ideal for occasional drying of meat jerkies, fruit leathers, banana chips or for preserving excess produce like celery or mushrooms. Because the oven is needed for every day cooking, it may not be satisfactory for preserving abundant garden produce. Oven drying is slower than dehydrators because it does not have a built-in fan for the air movement. (However, some convection ovens do have a fan). It takes about two times longer to dry food in an oven than it does in a dehydrator. Thus, the oven is not as efficient as a dehydrator and uses more energy.
Drying is a simple process of removing excess water content from an agricultural or industrial product. It is oldest method of food preservation. Most of the agricultural products contain the higher moisture of 25– 80% but generally for agricultural products around 70%.
This value of moisture content is very much higher than the

required for long preservation. Due to this moisture content bacterial and fungal growth is very fast in the crops. Bacteria and enzymes may spoil the foodstuff and reduces the nutrient content in it. Moisture content of crops to a certain level slows down the bacterial, enzymes, and yeasts effect (V. Belessiotis; E. Delyannis, 2011).

1.3 Infrared Drying

Infrared radiation (IR) is a part of the electromagnetic spectrum that is predominantly responsible for the heating effect of the sun. (Ranjan, R *et al*., 2002) [16]. The application of IR radiation in a stepwise mode by slow power increase and short cooling among power levels leads to less degradation of color than with alternate infrared heating. Chua, K.J *et al*., (2004) [17]

Drying can be defined as a mass transfer operation having a solid–gas interface. The largely general mass transfer operations containing two phases (distillation, gas absorption, and humidification) specify conditions having interfaces such as variables in space and time. (Holland, C.D *et al*., (1975) [18], McCabe, W.L.S *et al*., (1993) [19], Geankoplis, C.J *et al*., (1993) [20]

Infrared drying has become more popular in recent yearsbecause of its advantages, such as its low drying time, the reasonable quality of the final dried product, and its greater energy savings capability, in addition to its lower price compared to microwave and vacuum drying methods. When IR is used to dry or heat a material, it is absorbed by the solid material in its surface layer. Nevertheless, radiation penetrates to some depth in moist, porous materials; their ability to transmit depends on the moisture content. (Abukhalifeh, H *et al*., 2005) [22]

Drying at low temperature to enhance the quality of food products has been a growing interest in recent years. Heat pump have been known to be energy efficient when used in conjunction with drying operation (Chau *et al.,* 2002). Pal *et al.* (2008) proposed to dry the green sweet paper at 35°C in a heat pump to obtain an acceptable product.

Drying is an excellent way to preserve food and solar dryers are appropriate food preservation technology for sustainable development. Drying was probably the first ever food preserving method used by man, even before cooking.

To evaluate the drying characteristics of Spinach, Tomato, capsicum by

a) Tray dryer

b) Hot air oven drying

2. Materials and Methods

Samples were procured from local market and are checked for the quality and sorted out depending in its quality which are used for further processing. The vegetables are soaked in 150ml/25ml/ water for about an hour and are allowed to drain all the water and are dried in tray drying, hot air oven, Soaking is a traditional practice that can positively impact the nutritional qualities of the product. Soaking also helps drying early without much nutritional losses. The initial weight of the sample is taken and allowed to soak for 1 hour and again it was weighed and kept in tray /hot air oven/infrared/sun dryers.

2.1 Tray Drying

The tray drier is initially pre-heated to the required temperature (70 ℃and 80℃). The weighed sample is spread out, generally quite thin on trays in which a way that the hot air moves evenly through all particles of sample. Heating may be by an air current sweeping across the trays, by conduction from heated trays or heated shelves on which the trays lie, or by radiation from heated surfaces. Most tray dryers are heated by air, which removes the moist vapours.

The weights of the sample is taken for every 10 minutes and the process is continued till constant reading is obtained and the amount of moisture removed is calculated.

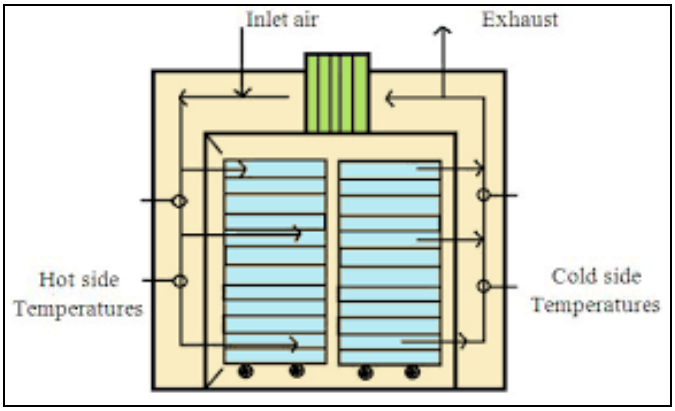

Fig 1: Tray drier

2.2 Hot air oven drying

Dry the empty dish and lid in the oven at 105 for 3 hours and transfer to desiccator to cool. Weigh the empty dish and lid. Weigh about 5 g of sample to the dish. Spread the sample to the uniformity. Place the dish with sample in the oven. Dry for 3 h at 105℃.After drying, transfer the dish with partially covered lid to the desiccator to cool reweigh the dish and its dried sample.

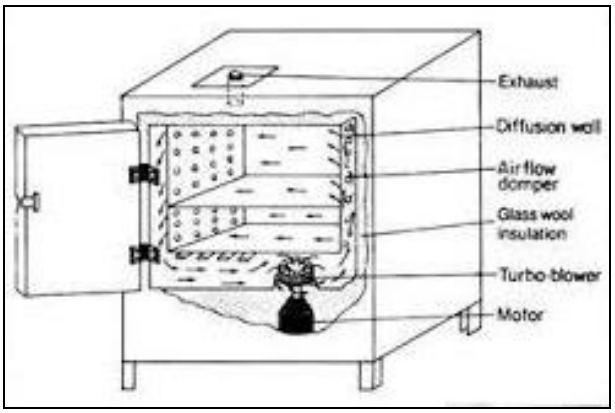

Fig 2: Hot air oven

2.3 Sun Drying

Sun drying is a traditional method for reducing the moisture content of vegetables by spreading the grains under the sun. The solar radiation heats up the grains as well as the surroundings air and thus increases the rate of water evaporating from the vegetables (spinach, tomato,

capsicum).It is the most common drying method in Asia because of its low cost compared to mechanical drying. It requires little investment.

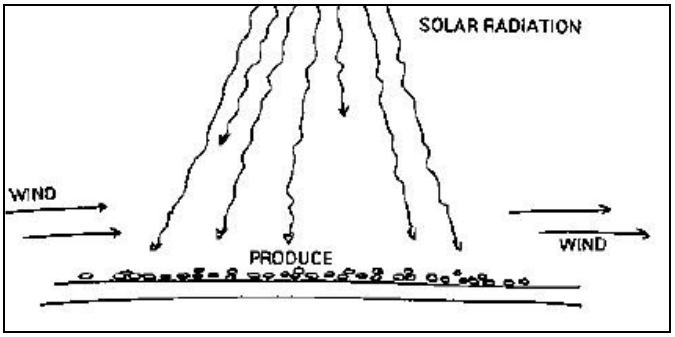

Fig 3: Sun drying

2.4 I R drying

Infrared heating involve a heat transfer by radiation between a hot element and a material at lower temperature that needs to be heated or dried. The peak wavelength of the radiation is dependant of the temperature of the heated element

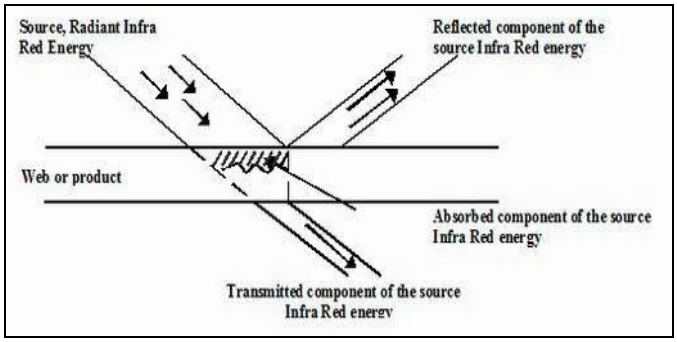

Fig 4: Infrared Red drying

3. Results and Discussions

3.1 Tray drying

In tray drying the selected drying temperature was70℃. The air dried leaves were loaded on the trays forming one single layer and were dried in the tray dryer by forced air technique. The tray dryer was preheated to selected temperature and then the loaded tray was added to dryer. The vegetables are soaked for 30 minutes and the following data is obtained.

Table 1: Soaking of Spinach, Tomato and Capsicum

Sample	Initial weight(g)	Soaking Water(ml)	Final wt(g) Time(min)	Volume of water retained (ml)	% Water of absorption	
Spinach	100	150	30	120	138ml	8
Tomato	100	150	30	118	133ml	11.3
Capsicum	100	150	30	123	135ml	10

Table 2: Try drying Final data

Sample	Reading for every 10min duration						Moisture content (%)
	1	2	3	4	5	6	
Spinach	114	109	104	101	97	93	27
Tomato	118	115	113	111	109	107	11
Capsicum	122	121.1	120.2	118.1	115.2	114	9

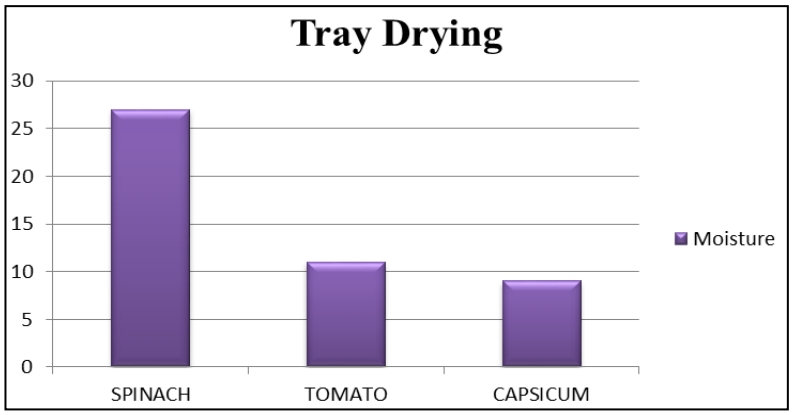

Fig 5: Tray drying results

3.2 Hot air oven drying

The drying chamber was constructed fromgalvanized metal sheets. Two electrical heaters were inside chamber used to provide the hot air. ARM 396 analogue heat control unit with digital indicator was used to determinate of air temperatures. The airflow rate was measured by Lutron- AM 4202 anemometer in the measurement range of 0.4-30 m/s. Drying chamber and air heating chamber was isolated with 30 mm glass wool and aluminum foil to prevent heat loses. Hot air drying experiments were performed at three drying temperature that was105°C and air velocities were adjusted as 1.5 and 2.5 m/s in hot air drying experiments.

The vegetables are soaked for 20 minutes and the following data is obtained.

Table 3: Soaking of Spinach, Tomato and Capscicum

Sample	Initial weight(g)	Soaking		Final weight(g)	% of water absorbed	Vol of Water retained (ml)
		Time (min)	Water (ml)			
Spinach	5	20	25	5.8	12	17ml
Tomato	5.1	20	25	5.7	8	18ml
Capsicum	5.1	20	25	5.6	16	16ml

Table 4: Hot air oven drying final data

Sample	Empty petric plate	Sample weight(g)	Total weight(g)	Weight after Drying	Moisture content (%) a-b*100		
		(W)	(a)	1hr	2hr	3hr(b)	W
Spinach	88.2	5.8	94	93.1	92.8	92.5	25.8
Tomato	70.1	5.7	75.8	75.3	74.8	74.3	26.3
Capsicum	68.8	5.6	74.4	74.2	73.8	73	25

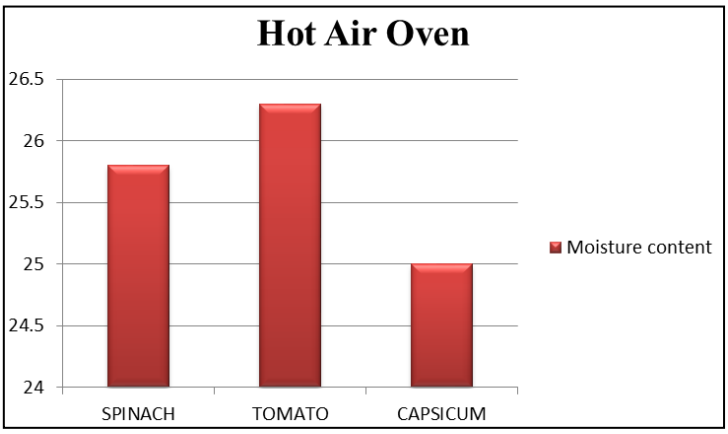

Fig 6: Hot air oven results

3.3 Infrared Drying

The appraisal of capsicum, tamato, spinach treated with infrared heating below table showed the results of infrared drying.NIR drying of un blanched spinach, tamato, capsicum were done at the density of radiation approximately 5000 W m-2, at wavelength peak of 1 µm, at air temperature 23ºC and air velocity 0.5 m/s. Drying of spinach, tamato, and capsicum slices, was natural and also was done with or without preliminary blanching but at the density of radiation approximately 4760 W m-2 and at wavelength peak 1.8 µm. The distance between emitter and dried products was 100 mm. The surrounding air temperature was 29 ºC approximately.

Table 5: Infrared Drying

Sample	Initial weight (g)	Moisture content reading (%)					
		10min	20min	30min	40min	50min	60min
Spinach	10	10	13.1	17.1	19.8	21.2	22.3
Tomato	10	11.2	12.3	14.3	16.1	16.2	18.2
Capsicum	10	9	10.2	13.3	14.2	15.3	17.6

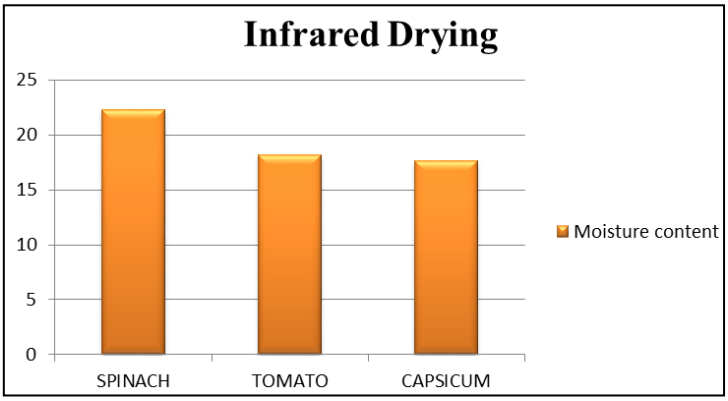

Fig 7: Infrared drying results

3.4 Sun Drying

Perforated sample trays were used in sun drying experiments (Figure2.3). These trays were assembled to wooden frame in the size of 80x100 cm on 80 cm stands to prevent from contamination. During the drying of tomato slices, spinach, Capsicum slices, the ambient air temperature, relative humidity and wind speed values were determined between 30-34.8°C, 31.20-40.50%, 0.7-2.9 m/s, respectively. Open sun drying experiments were done between 09:30 and 18:30.

Table 6: Sun Drying

Sample	Sample weight(g)	Weight after soaking in water(g)	Weight after Drying				Moisture content (%)
			15min	30min	45min	60min	
Spinach	50	57.2	54.6	52.2	50.1	48.2	18
Tomato	50	56.1	54.2	52.3	49.3	47.1	18
Capsicum	50	55	53.1	52.1	50.2	48.6	12.8

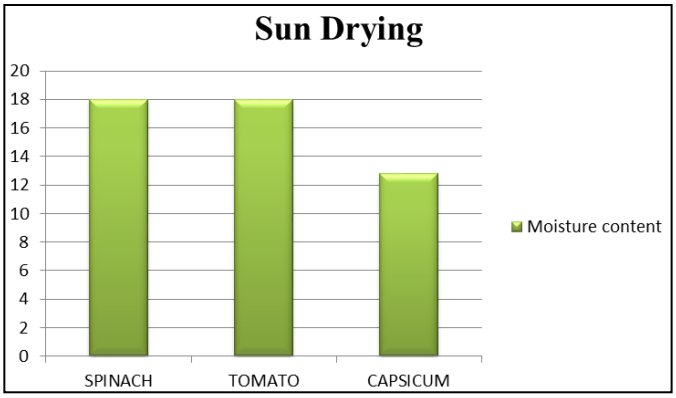

Fig 8: Sun drying results

4. Conclusions

The three drying methods used greatly affected the drying characteristics vegetables (Spinach, Tomato and Capsicum). The commonly consumed Spinach, Tomato and Capsicum were dried under tray dryer, hot air oven drying, Infrared and Sun Drying. The drying characteristic and time required for drying of Spinach, Tomato and Capsicum were studied and final dry weight of the Spinach, Tomato, soybean, were estimated. It was found that Spinach, Tomato, capsicum samples, dried by hot air drying were reported to take minimum time for drying with maximum removal of moisture. The samples are dried in hot air dryer at 105℃ gives better results in maintaining better appearance, color and texture.

5. Acknowledgement

We acknowledge the University College of technology, Osmania University funding this research. We deem it our privilege to express gratitude with exaltation to Mr. V. Bhasker Assistant Professor, University College of technology, Osmania University, Hyderabad, for his insightful guidance. Sincere thanks to Mr. Srinivasa Maloo due to his transcendent suggestions, valuable comments and efforts to embellish the study.

6. Reference

1. AOAC. Official methods of analysis 14th ed. Washington, DC, 1984-2014.
2. AOAC. Official Methods of the Association of Analytical Chemists, AOAC International, Washington, DC, USA, 15th edition, 1990.
3. Choi BM, Lee CH, Park SJ. A study on drying characteristics and drying model development of Korean ginseng. Korean Journal of Ginseng Science. 1992; 16:111-123.
4. Chemistry of spices by Parthasarathy VA, Bhageerathy Chempakam T. John Zacharaiah, 2008.
5. Handbook of Analysis and Quality control for fruits and vegetables by Ranganna S.
6. Kalra SK, Bhardway KC. Use of simple solar dehydrator for drying fruits and vegetable products. J Food Sci. Technol. 1981; 8(1):23-26.
7. Mebrahtom Gebrelibanos, Dinka Tesfaye, Raghavendra Y, Biruk Sintayey. Nutritional and Health Implications of Vegetables**,** International Journal of Pharmaceutical Sciences and Research.
8. Mazur WM, Duke JA, Wahala K, Rasku S, Adlercreutz H. Isoflavonoids. lignans in vegetables: Nutritional and health aspects in humans. Nutritional Biochemistry.1998; 9(1):93-200.
9. Naseer Ahmed, Jagmohan Singh, Harmeet Chauhan, Prerna Gupta Anisa Anjum, Harleen Kour. Different Drying Methods: Their Applications and Recent Advances. International Journal of Food Nutrition and Safety. 2013; 4(1):34-42, ISSN: 2165-896X.
10. Prasanna Guda Shruthi Gadhe Sandhya Jakkula. Drying of Cocoa Beans by Using Different Techniques. International Journal of Agriculture Innovations and Research, 2017; 5(5), ISSN (Online) 2319-1473.
11. Gupta P, Ahmed J, Shivhare US, Raghavan GSV. Drying Characteristics of Red Chilli. Drying Technology. 2002; 20(10):1975-1987-2002.
12. Gupta P, Ahmed J, Shivare US, Raghavan GSV. Drying characteristics of red chilli. Drying Technology. 2002; 20(10):1975-1987.
13. Vishal Kumar BR, Singh Samsher Suresh Chandra, Sweta Singh. A Review on Tomato Drying by Different Methods with Pretreatments, International Journal of Food and Fermentation Technology. 2015; 5(1):15-24.
14. Hasturksahin F, Aktas T, Orak3 H, Ulgerinfluence P. of pretreatments and different drying methods on color parameters and lycopene content of dried tomato, Bulgarian Journal of Agricultural Science. 2011; 17(6):867-881.
15. Wade NC, Wane SS, Kshirsagar SM. comparative study of drying characteristics in chillies, Ind. J. Sci. Res. and Tech. 2014; 2(3):105-111.
16. Ranjan R, Irudayaraj J, Jun S. Simulation of infrared

drying process. Drying Technology. 2002; 20(2):363-379.
17. Chua KJ, Chou SK, Mujumdar AS, Ho JC, Hon CK. Radiant–convective drying of osmotic treated agro-products: Effecton drying kinetics and product quality. Food Control. 2004; 15(2):145-158.
18. Holland CD. Fundamentals and Modeling of Separation Processes; Prentice Hall: Englewood Cliffs, NJ, 1975.
19. McCabe WLS, Harriot P. Unit Operations of Chemical Engineering; McGraw-Hill, International Edition: New York, 1993.
20. Geankoplis CJ. Transport Processes and Unit Operations; PrenticeHall: Englewood Cliffs, NJ, 1993.
21. Ravi Kumar, Vivak Kumar, GR Singh, BR Singh, Samsher, Jaivir Singh, Pushpendra Kumar. Drying characteristics of green chillies under different dryer, International Journal of Chemical Studies. 2017; 5(4):407-409.
22. Abukhalifeh H, Dhib R, Fayed ME. Model predictive control of an infrared-convective dryer. Drying Technology. 2005; 23(3):497-511.
23. wade1 NC, wane SS, kshirsagar SM. Comparative study of drying characteristics in chillies, Ind. J sci. res. and tech. 2014; 2(3):105-111.
24. Bakane PH, Khedkar MB, Wankhade AB, Kolhestudies RV. On drying of green chilli in dehumidified air dryer, international journal of processing and post harvest technology. 2014; 5(2):127-130.