

Experimental Investigation of Ginger (*Zingiber Officinale* Roscoe) Drying

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Abstract— Drying is one of the primogenital methods of food preservation. Ginger is a tropical species native to South East Asia and it is used as a spice and as a preserve in the dry state. In this experimentation, the Ginger dryer was developed of 0.5 m³ capacity. Average 63°C temperature was maintained during the trial of 360 min. duration. Moisture % removal analysis done with the location of samples. The maximum % of moisture removal in 360 min. is 34% from rack 3. The Prandtl number and the Nusselt

Number observed more at the rack one.

Index Terms— Drying, Ginger, Moisture removal.

I. INTRODUCTION

Drying preserves foods by removing enough moisture from food to prevent decay and spoilage. The water content of properly dried food varies from 5 to 25 percent depending on the food. Ginger is the underground stem (rhizome) of a perennial herb, which is used as a spice and as a preserve in a dehydrated condition. It is the most popular hot spice in the world.

Ginger can be used in culinary use, urinary infection, in migraine resolution, acne treatment, as a toner, stomach infection, effective in a headache, chest pain, common cold, metabolism, weight loss, carminative, antioxidant, reduces cancer in ovaries.

Important flavor compounds in ginger are gingerol, shogaol, neral, geranial. Nutritional composition of ginger as USDA and ASTA is given in table 1.

Table 1: Nutritional composition of ginger per 100gm.

Composition	USDA [§] (Ground)	ASTA [#]
Water (g)	9.38	7.0
Food energy (Kcal)	347	380
Protein (g)	9.12	8.5
Fat (g)	5.95	6.4
Carbohydrates (g)	70.79	72.4
Ash (g)	4.77	5.7
Calcium (g)	0.116	0.1
Phosphorus (mg)	148	150

Sodium (mg)	32	30
Potassium (mg)	1342	1400
Iron (mg)	11.52	11.3
Thiamine (mg)	0.046	0.050
Riboflavin (mg)	0.185	0.130
Niacin (mg)	5.155	1.30
Ascorbic acid (mg)	ND*
Vitamin A activity (RE)	15	15

[§]Composition of Foods: Spices and Herbs, USDA Agricultural Handbook 8-2, Jan. 1977.

[#]The Nutritional Composition of Spices, ASTA Research Committee, Feb. 1977.

*ND = Not Detected.

In India plantation area and yield production of ginger is witnessed in growing trend from 2012-13 (Table 2). This rising yield leads for further revenue generation in the form of export from India (Table 3).

Table 2: Year-wise ginger plantation area and production yield in India

Year	Area (Hectare)	Production (Tonn)
2012-13	134430	669350
2013-14	138200	683160
2014-15	153100	795820
2015-16	156910	1025110
2016-17	164850	1081430

Table 3: Year-wise export of ginger quantity and value

Year	Quantity (Tonn)	Value (Lakhs)
2012-13	22207	18725.14
2013-14	23300	25614.27
2014-15	40400	33133
2015-16	24800	27595.56
2016-17	24950	25705

(State Agri/Hort. Departments/DASD Kozhikkode

Spices Board of India)

As per the above scenario of global export of ginger as an important spice, a lot of effort was made to study moisture removal process. Puengphian and Sirichote observed that fresh mature ginger rhizomes with 94.17 ±0.16% moisture content were dried using a rotary air dryer at 55 ± 2°C for 11 hours to achieve a moisture content of 11.54 ±0.29% [1]. The Study conducted by An et al. ginger

rhizome slices were subjected to air drying (AD), freeze drying (FD), infrared drying (IR), and microwave drying (MD) and intermittent microwave and convective drying (IM&CD). Results showed that AD and IR were good drying methods to preserve volatiles. However, FD and IR had relative high energy consumption and drying time [2].

Ding et al. investigated dehydrated by air drying (AD), microwave drying (MD), vacuum drying (VD), and freezing drying (FD). Cluster analysis disclosed that MD was the most favorite drying way, followed by AD at 60 °C, VD, FD, and AD at 50 and 70°C [3].

Chapchaimoh et al. studied drying performance and energy consumption of a closed system heat pump dryer for ginger drying at 50°C within 200 minutes using air and nitrogen as the drying medium. The fresh ginger at a moisture content of 777 was dried by air and nitrogen down to 132 and 89 % dry basis. Air drying required total input energy of 11.6 compare to the nitrogen of 12.5 MJ. Specific moisture extraction rate of ginger drying in the air was 0.06 while nitrogen was 0.07 kg water/MJ [4].

Aritesty and Wulandani experimented with the rack type solar dryer. It is observed that the best of drying performance is the drying of 60 kg slice wild ginger at 47.2°C for 30 hours represented by drying efficiency of 8 % and total energy consumption of 29 MJ/kg vapor [5].

From the survey of literature on ginger drying, it is observed that drying temperature range selected is 50) C to 70°C. Drying duration varies from 200 min to 30hours. Based on summary of above literature, special ginger dryer was developed.

II. EXPERIMENTATION

The ginger dryer consists of a blower, electric heater and dryer box (Fig. 1). Atmospheric air is delivered to the heater by an air blower (Crompton make, 1200 CFM). The coil type electric heater (1 KW) supply heat energy to the fresh air. The electric dimmer is used to control electric supply to heater and supply controlled heating. The special duct of reducing cross-sectional area supplies hot air to dryer box uniformly. Dryer box manufactured with plywood (18 mm) with the volume of 0.49 m³. Drying products are placed on three wire mesh trays fitted at equidistance. The thermocouples (PT100) are used to measure the temperature at five locations (Table 4). The temperatures are recorded manually with the help of temperature indicator. The velocity of inlet hot air to dryer box is measured with hot air anemometer (Lutron make AM 4204). Moist air from the outlet of dryer box allowed to pass to atmosphere freely.

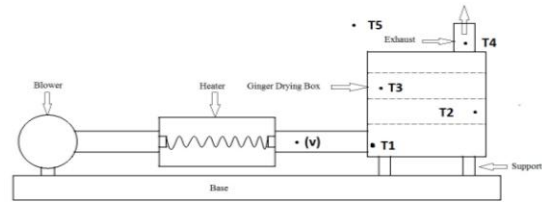


Figure 1: Block diagram of ginger dryer setup.

Hand picked fresh ginger from local market are used for experimentation. Fresh ginger cut into slice of approx. 3 -4 mm thickness. Before starting trial 36 samples of approx. 25 gram is prepared. Weighing of ginger done on the digital weighing machine (HMT make, 0.01 gram). After recording initial weights, twelve samples of ginger were placed on top (rack 1), middle (rack 2) and bottom rack (rack 3) respectively.

Total trial duration is 360 min. After the duration of 30 min., one sample from each rack i.e. from the top, middle and bottom are taken out from the dryer. The weight of this sample was recorded manually. A number of trials were conducted to reduce random errors.

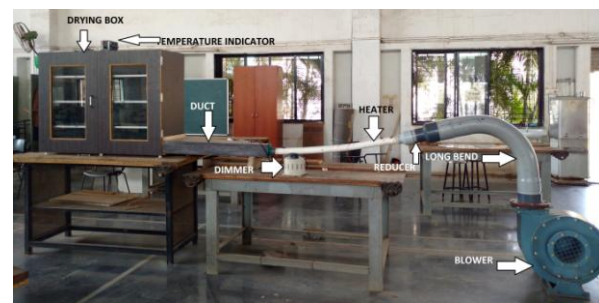


Photo 1: Actual ginger dryer setup.

Table 4: Thermocouple locations.

Sr. no.	Thermocouple	Location
1	T1	At the entrance to the drying box
2	T2	Between 1 st & 2 nd net tray
3	T3	Between 2 nd & 3 rd net tray
4	T4	At the exit of the drying box
5	T5	Atmospheric temperature

III. RESULTS AND DISCUSSION

% moisture loss was calculated and averaged. The temperature of the box increases with increase in drying duration. The heated air is entering in dryer box, come in contact with three racks. The third rack is at the entry to the heated air. Thus, the third rack gets more heat energy as compared to the first and second rack.

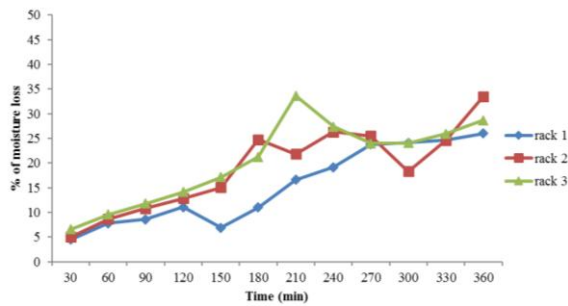


Figure 2: % of moisture loss Vs drying duration.

The % of moisture loss of the third rack is 6% at initially (after 30 min. duration). The first and second rack is having 4% to 5% of moisture loss. As time increases the % of moisture removal increases. The third rack is having the maximum % of moisture removal. The maximum % of moisture removal in 360 min. is 34%.

The temperature of racks is initially at same level i.e. 30°C. It is observed that the inlet temperature was more than the outlet and average temperature. The temperature at exit decreases, as it supplies heat to the ginger and the interior of dryer box.

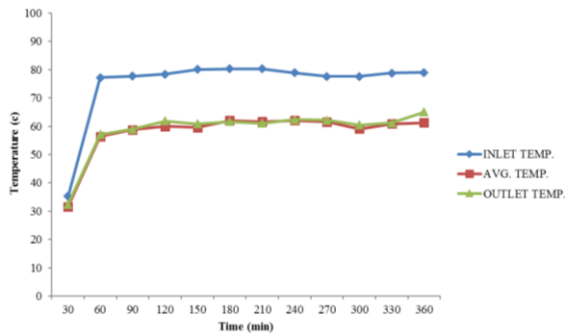


Figure 3: Average temperature Vs drying duration

After two hours the temperature of each rack starts to be approximately constant for further four hours. The maximum temperature at the inlet is 80°C and outlet is having a maximum temperature of 65°C. The maximum temperature at average is 63°C.

The Prandtl number depends upon the dynamic viscosity of air, specific heat of air and thermal conductivity of air at that temperature. As specific heat and dynamic viscosity of air increase the Prandtl number also increases. But as the thermal conductivity of air increases the Prandtl number decreases. Prandtl number is more at starting because the thermal conductivity of air is less at the starting. But as the temperature increases with time, the thermal conductivity of air also increases.

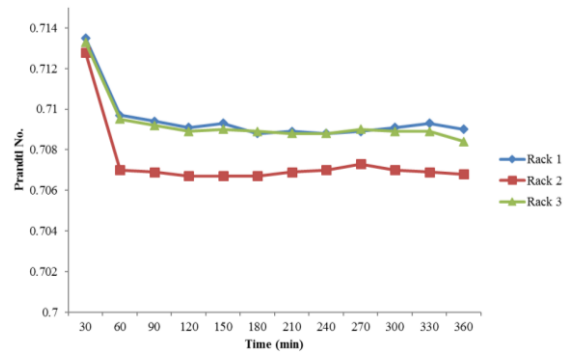


Figure 4: Prandtl's No. Vs drying duration

The Prandtl number is 0.7135 at the starting but it reaches to 0.707 at the minimum. The Prandtl number is more at the first rack where the thermal conductivity is less as compared to other two racks.

The Nusselt number depends upon the convective heat transfer coefficient, characteristic length and thermal conductivity of air at that temperature. Nusselt number is directly proportional to the convective heat transfer coefficient and characteristic length. As the characteristic length and convective heat transfer coefficient of air increase the Nusselt number also increases. But as the thermal conductivity of air increases the Nusselt number decreases. Nusselt number is more at starting because the thermal conductivity of air is less at the starting. But as the temperature increases with time, the thermal conductivity of air also increases.

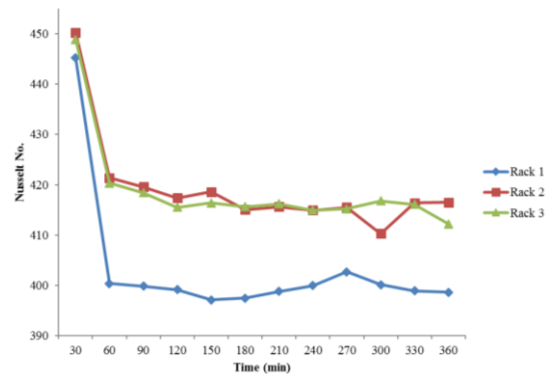


Figure 5: Nusselt No. Vs drying time duration

The maximum Nusselt number is 450 at the starting but it reaches to 399 at the minimum at the outlet. The Nusselt number is more at the first rack where the thermal conductivity is less as compared to other two racks.

IV. CONCLUSION

Based on the results of the present investigation, the

conclusion can be made that ginger drying with dryer box has profound effect on the % of moisture loss of dehydrated product. The third rack is having the maximum 34 % of moisture removal in 360 min. The maximum average temperature maintained in dryer box is 63⁰C. The Prandtl number and the Nusselt number is more at the first rack where the thermal conductivity is less as compared to other two racks.

Drying of ginger needs to be carried out to calculate exact drying duration required to make dry ginger dry (Moisture less than 10 %). Dryer box with some modification can be utilized to dry variety of fruits, vegetables.

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