

Studies on drying kinetics of ginger slices

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Abstract

In the present research work attempt were made to evaluate the drying rate of ginger slices by drying it in cabinet dryer. Different sizes of ginger were taken i.e. 5, 10 and 15 mm for drying. After every 20 min weight loss was recorded. The experiments were carried out for four different temperatures of 50, 60, 70°C by keeping the air velocity fixed at 1.3 m/s. It could be observed from the experiment that the moisture content of sliced ginger is decreasing with increase in drying time under all the treatments. Among the three sizes of ginger slice (i.e. 5, 10 & 15 mm) the removal of moisture is more in case of 5 mm slice followed by 10 mm and 15 mm. The higher moisture removal in case of 5 mm thick slices. Among the three drying temperatures, the loss of moisture reported to be higher in case of T₃ followed by T₂ and T₁

Keywords: ginger slices, drying kinetics, cabinet dryer

Introduction

Drying is a process of removing moisture from products to reduce weight and volume that will facilitate packaging, storage, and transportation. Drying also helps in improving product stability during storage by preventing microbial contamination caused by the presence of moisture content. Convection oven drying is a widely-used drying method in the local herbal industry due to its simple operation. Optimization using this method is essential to ensure products are dried appropriately to minimize degradation. Previous studies conducted on cocoa had revealed that the use of high temperature is often compromised by degradation or loss of quality of the product (Alean *et al.*, 2016) ^[1]. Material dried in a controlled way may contribute to the more uniform distribution of the moisture content during drying (Kowalski *et al.*, 2005) ^[2].

Drying is a technique of conservation that consists of the elimination of large amount of water present in a food by the application of heat under controlled conditions, with the objective to diminish the chemical, enzymatic and microbiological activities that are responsible for the deterioration of foods (Barnabas *et al.*, 2010) ^[3]. Water removal is the main task while preserving food (Lenart, 1996) ^[4] reducing the moisture contents to a level, which allows safe storage over an extended period of time.

Materials and Methods

Ginger

Freshly harvested gingers are properly washed in fresh running water and then they are cut into slices of 5, 10, 15 mm thickness by a knife. The initial moisture content of the sliced ginger is determined by using hot air oven method.

Drying equipment

The dryer used for the present experiment is a batch type

cabinet dryer, of Agricultural Produce Processing Division, CIAE, Bhopal, MP, India. It consists of a heating chamber, a drying chamber, an air filter, an exhaust fan, a Proportional Integral Derivative (PID) controller and an electronic balance.



Plate 1: Ginger slices of thickness 5 mm



Plate 2: Ginger slices of thickness 10 mm



Plate 3: Ginger slices of thickness 15 mm

Drying experiment

Drying experiment was conducted at different temperatures

50, 60, 70 °C for slices of thickness 5, 10, 15 mm with two replications of each. Before starting the experiment the dryer is preheated for half an hour with set temperature and velocity. The sliced ginger of 50 g weight is spread uniformly in a thin layer on to the sample tray. The temperature and the velocity of the hot air are measured just before the sample tray. The weight loss is recorded from the electronic balance at 20 min interval. The balance is having weighing capacity of 250 g and

readability 0.01 g. The experiments are carried out for four different temperatures of 50, 60, 70°C by keeping the air velocity fixed at 1.3 m/s. The drying process is stopped when the moisture content of the sample reached 6-7 % (w.b). The drying experiments are replicated two times for each temperature and the average values are taken. The quality of the dried product is ensured based on the criteria of color through visualization, taste and smell.

Results and Discussion

Table 1: Observations recorded at Temperature 50°C (T1)

Time, min	Weight, gm			Moisture removed			Moisture Content % db			Drying Rate gm/min		
	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3
0	50.00	50.00	50.00	0.00	0.00	0.00	737.0	737.0	737.0	0.0000	0.0000	0.0000
20	44.44	45.40	45.12	5.57	4.60	4.88	641.8	657.9	653.3	0.0167	0.0138	0.0146
40	41.04	42.88	42.74	3.40	2.52	2.39	585.1	615.9	613.4	0.0102	0.0075	0.0071
60	38.08	40.79	40.55	2.97	2.09	2.19	535.6	581.0	576.9	0.0089	0.0063	0.0066
80	34.58	38.53	38.25	3.50	2.26	2.30	477.2	543.2	538.5	0.0105	0.0068	0.0069
100	31.80	36.46	36.08	2.78	2.07	2.17	430.9	508.7	502.3	0.0083	0.0062	0.0065
120	28.78	34.52	33.90	3.03	1.94	2.18	380.4	476.3	465.9	0.0091	0.0058	0.0065
140	25.99	32.46	31.87	2.79	2.07	2.03	333.9	441.8	432.1	0.0083	0.0062	0.0061
160	24.03	31.05	30.54	1.96	1.41	1.33	301.2	418.4	409.8	0.0059	0.0042	0.0040
180	21.44	29.10	28.52	2.60	1.95	2.02	257.8	385.8	376.1	0.0078	0.0058	0.0060
200	19.33	27.91	27.34	2.11	1.19	1.18	222.6	365.9	356.4	0.0063	0.0036	0.0035
220	17.72	26.80	26.38	1.61	1.11	0.96	195.8	347.4	340.4	0.0048	0.0033	0.0029
240	16.02	25.68	25.28	1.71	1.12	1.11	167.4	328.7	322.0	0.0051	0.0034	0.0033
260	14.22	24.31	24.05	1.80	1.37	1.23	137.4	305.8	301.4	0.0054	0.0041	0.0037
280	12.85	23.24	22.95	1.37	1.07	1.10	114.5	288.0	283.1	0.0041	0.0032	0.0033
300	11.40	22.14	21.73	1.45	1.10	1.22	90.3	269.6	262.7	0.0043	0.0033	0.0037

Table 2: Observations recorded at Temperature 60°C (T2)

Time, min	Weight, gm			Moisture removed			Moisture Content % db			Drying Rate gm/min		
	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3
0	50.00	50.00	50.00	0.00	0.00	0.00	737.0	737.0	737.0	0.0000	0.0000	0.0000
20	43.53	45.12	46.01	6.47	4.89	4.00	626.7	653.2	668.0	0.0194	0.0146	0.0120
40	37.68	40.54	42.52	5.85	4.58	3.49	529.0	576.8	609.8	0.0175	0.0137	0.0105
60	32.41	36.48	39.42	5.27	4.06	3.10	441.1	509.0	558.1	0.0158	0.0122	0.0093
80	26.79	31.89	36.11	5.63	4.59	3.32	347.2	432.4	502.8	0.0168	0.0137	0.0099
100	22.62	30.05	33.50	4.17	1.84	2.61	277.6	401.7	459.3	0.0125	0.0055	0.0078
120	18.97	25.44	31.11	3.66	4.61	2.40	216.6	324.7	419.3	0.0109	0.0138	0.0072
140	15.20	22.28	28.61	3.77	3.17	2.50	153.7	271.9	377.5	0.0113	0.0095	0.0075
160	12.52	19.79	26.62	2.68	2.49	1.99	109.0	230.3	344.3	0.0080	0.0075	0.0060
180	9.95	17.40	24.62	2.57	2.39	2.00	66.1	190.5	310.9	0.0077	0.0071	0.0060
200	7.84	15.30	22.87	2.11	2.11	1.75	30.9	155.3	281.8	0.0063	0.0063	0.0052
220	6.34	13.38	17.34	1.50	1.92	5.53	5.8	123.3	189.5	0.0045	0.0058	0.0040

Table 3: Observations recorded at Temperature 70°C (T3)

Time, min	Weight, gm			Moisture removed			Moisture Content % db			Drying Rate gm/min		
	S1	S2	S3	S1	S2	S3	S1	S2	S3	S1	S2	S3
0	50.00	50.00	50.00	0.00	0.00	0.00	736.99	736.99	736.99	0.0000	0.0000	0.0000
20	40.17	41.27	43.01	9.83	8.73	6.99	570.62	588.98	618.03	0.0294	0.0261	0.0209
40	33.96	36.54	38.93	6.22	4.74	4.09	466.86	509.93	549.83	0.0186	0.0142	0.0122
60	28.28	32.34	35.41	5.68	4.20	3.52	372.04	439.82	491.07	0.0170	0.0126	0.0105
80	23.13	28.57	32.10	5.15	3.77	3.31	286.14	376.96	435.81	0.0154	0.0113	0.0099
100	18.53	25.21	29.36	4.61	3.36	2.74	209.27	320.87	390.07	0.0138	0.0101	0.0082
120	15.39	22.72	27.32	3.14	2.50	2.04	156.84	279.22	356.09	0.0094	0.0075	0.0061
140	12.43	20.18	25.01	2.96	2.54	2.32	107.51	236.81	317.45	0.0089	0.0076	0.0069
160	10.42	18.45	23.29	2.01	1.73	1.72	73.96	208.01	288.73	0.0060	0.0052	0.0052
180	8.46	16.45	21.35	1.97	2.01	1.94	41.15	174.54	256.43	0.0059	0.0060	0.0058
200	6.98	14.75	19.59	1.48	1.70	1.77	16.53	146.16	226.96	0.0044	0.0051	0.0053
220	6.21	13.60	18.43	0.77	1.15	1.16	3.67	127.05	207.68	0.0023	0.0034	0.0035

Observations

1. Drying characteristics

a. Moisture content vs drying time

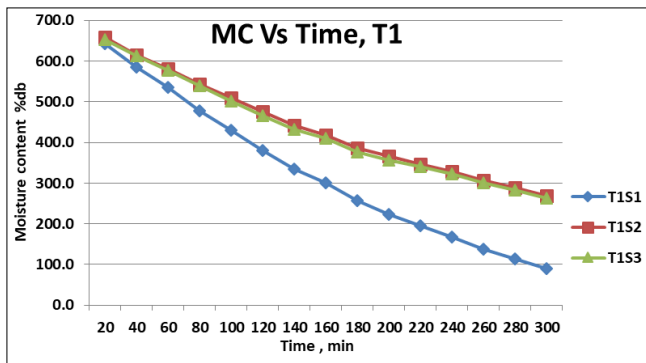


Fig 1: Moisture content Vs Time at temperature 50°C

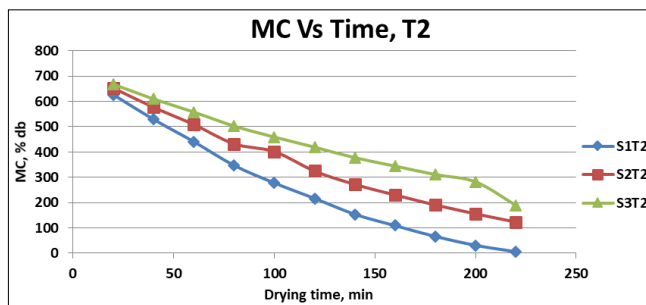


Fig 2: Moisture content Vs Time at temperature 60°C

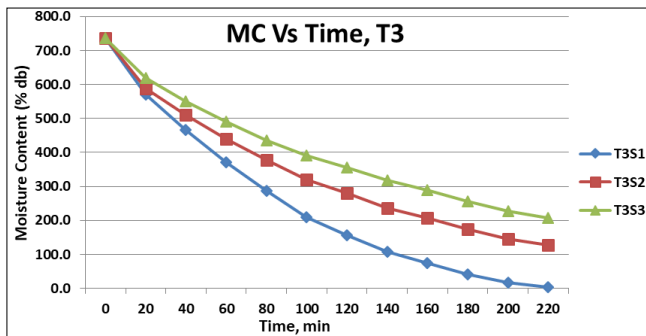


Fig 3: Moisture content Vs Time at temperature 70°C

It could be observed from the above figures that the moisture content of sliced ginger is decreasing with increase in drying time under all the treatments. Among the three sizes of ginger slice (i.e. 5, 10 & 15 mm) the removal of moisture is more in case of 5 mm slice followed by 10 mm and 15 mm. The higher moisture removal in case of 5 mm thick slice might be due to more exposed surface area and exposure of thin surface to heated air. Therefore the diffusion rate of moisture might be more.

Among the three drying temperatures, the loss of moisture reported to be higher in case of T3 followed by T2 and T1

Drying rate vs moisture content

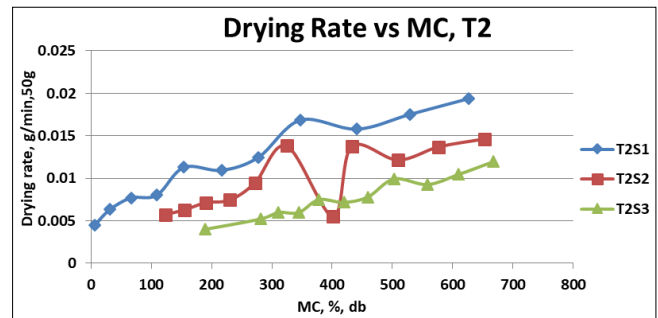


Fig 4: Drying rate vs. moisture content at 50° C

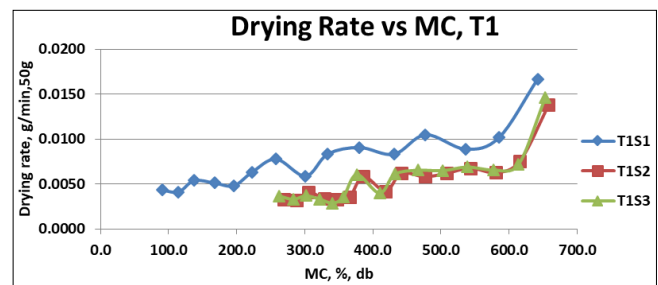


Fig 5: Drying Rate Vs Moisture Content at temperature 60°

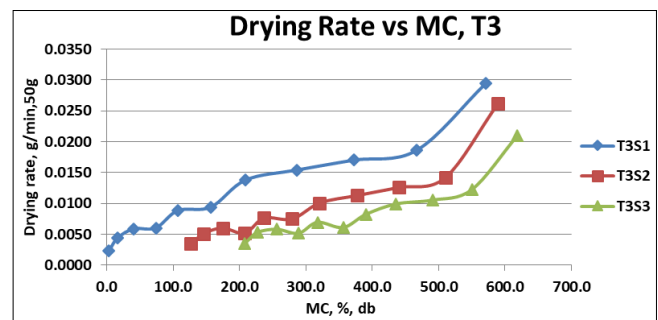


Fig 6: Drying Rate vs. Moisture Content at temperature 70°C

The changes of drying rate with moisture content under different temperatures are shown in figures. From the figures it was noted that during process of drying the ginger slices didn't show any constant rate drying period and complete drying takes place only in the falling rate period. It was also found that moisture content of the slices at any time was directly proportional to drying rate i.e. as the moisture content of the product decreased, the drying rate also decreased. Maximum drying rate w.r.t moisture content was noted for the slices treated at 70°C.

c) Drying rate vs drying time

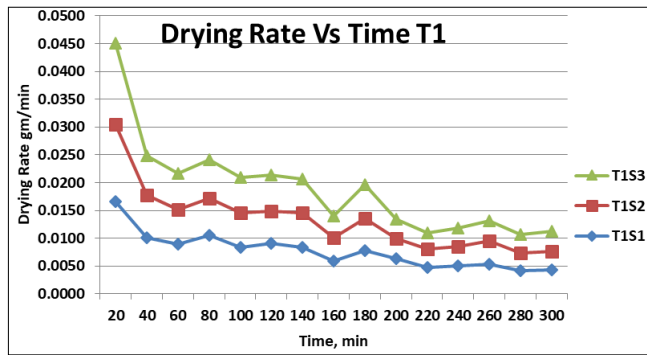


Fig 7: Drying Rate Vs Time at temperature 50°C

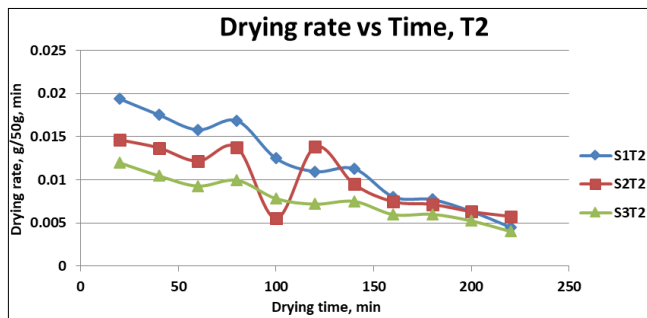


Fig 8: Drying Rate Vs Time at temperature 60°C

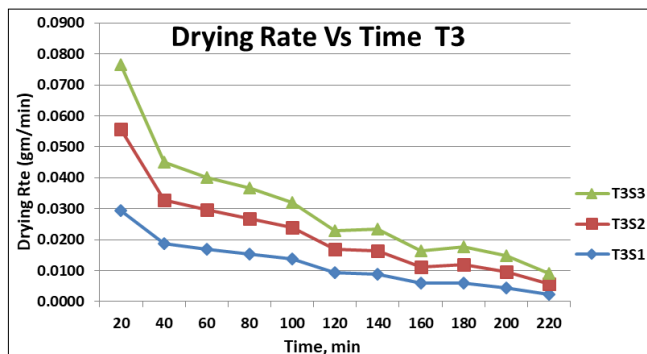


Fig 9: Drying Rate Vs Time at temperature 70°C

The changes of drying rate with drying time under different temperatures are shown in figures. It is evident from the figure that the maximum drying rate was observed during initial stages of drying. As the drying time increased, drying rate decreased showing an inverse proportion between the drying rate and drying time. The drying rate was found to be maximum for the slices treated at 70°C.

Conclusion

Drying studies carried out in batch cabinet dryer showed that higher the temperature, the higher the drying rate and the shorter the time required to achieved the constant moisture content. During process of drying the ginger slices didn't show any constant rate drying period and complete drying takes place only in the falling rate period. It was also found that moisture content of the slices at any time was directly proportional to drying rate i.e. as the moisture content of the

product decreased, the drying rate also decreased. Maximum drying rate w.r.t moisture content was noted for the slices treated at 70°C.

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