Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2016; 5(6): 384-390
Received: 22-09-2016
Accepted: 23-10-2016

Anurag
Department of Agricultural Process and Food Engineering, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

Neelesh Chauhan
Department of Agricultural Process and Food Engineering, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

Akash Singh
Department of Genetics and Plant Breeding, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pardesh, India

Mahendra Pratap Singh
S.M.S. Crop physiology, KVK Tissuhi Sonbhadra NDUAT Kumargaj Faizabad, Uttar Pradesh, India

Correspondence
Anurag
Department of Agricultural Process and Food Engineering, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

Drying characteristics of dried banana chips (*Musa paradisiaca* L.) under different types of dryers and pretreatments

Anurag, Neelesh Chauhan, Akash Singh and Mahendra Pratap Singh

Abstract
This study was done on "drying characteristics of dried banana chips under different types of dryers and pretreatments". Drying is the removal of the majority of water contained in the fruit or vegetable and is the primary stage in the production of dehydrated fruits and vegetables. The study of drying behavior of different materials has been the subject of interest for various investigators on both theoretical and practical grounds. In the course of studies conducted regarding the drying behavior of various agricultural products, Chips are an important ingredient in breakfast cereals. In the present study, the effects of different dryers temperatures and pretreatments on the drying characteristics of unripe banana chips were investigated control and pre-treated (KMS and NaSHO4). The samples were treated with KMS (Potassium metabisulfite) 1% and NaSHO4 (Sodium bisulfate) 1% for 4 minutes and during drying the hot air oven temperatures, tray drying temperatures used will be 60°C, 70°C, and 800C, and microwave oven temperatures used will be 40, 60 and 80 W. During drying, the range of air velocity will be 0.8-1.0 m/s.

Keywords: Banana, Chips, Moisture content, Drying rate, Moisture ratio, Snack foods

Introduction
Banana (*Musa paradisiaca* L.) is the common name for herbaceous plants of the genus Musa. Bananas come in a variety of sizes and colors when ripe, including yellow, purple, and red. In popular culture and commerce, "banana" usually refers to soft, sweet "dessert" bananas. Banana is the largest produced and maximum consumed amongst the fruits cultivated in India. It is known as the ‘common man's fruit'. It is highly nutritive and very delicious. India ranks first amongst the banana cultivating countries of the world with an annual production share of 25% of the total harvest. Unripe banana represents good source & indigestible carbohydrate due to the starch content or pulp and high cellulose, hemicelluloses & lignin level (Pekke et.al, 2004) [6]. Unripe banana consists mainly of starch (Nimsung *et al*, 2007) [4]. In India, out of 16.81 million metric tonnes, annual production of banana (Singh, and Uma, 1996) over 30% of the produce is wasted due to postharvest loses. One of the oldest and developing methods of food preservation is drying process that provides an extension of shelf life besides the preservation of product quality, for example, nutritional value, flavor, aroma, color, and structure. Fruits like banana have high sugar needs temperature and longtime reach safe moisture during drying. Banana fruits are variable in size shape and color. They generally elongate cylindrically, straight to strongly curved, 3-40 cm (1.2-16 inch) long, and 2-8 cm (0.8-3 inch) in diameter. Inside the fruit, the flesh ranges from starchy to sweet, and in color from white, cream, yellow, or yellow-orange to orange. The fruits grow in clusters hanging from the top of the plant. It contains 75% is water and 25% dry matter. The fruit is considered an excellent source of Potassium, K (1491mg/100gm). It has an appreciable quantity of Iron, Fe (1.15 mg/100gm), Magnesium, Mg (108 mg/100gm), Phosphorus, P (74 mg/100gm). Banana is a fruit that is rich in the natural antioxidants such as a vitamin C and vitamin E. The antioxidants properties of many fruits are associated with flavonoids and beta- carotenes. Flavonoid is found in the pulp and peel of banana while beta-carotenes are present only in the pulp of some banana varieties (Vijayakumar *et al*., 2008) [9]. Beta-carotenes are precursors of vitamin A. In low-income regions of the world, such as parts of Asia, Africa and Latin America, high levels of vitamin A deficiency lead to the serious health problem, especially in the children (Bloem *et al*., 2004) [2]

Materials and methods
The investigation was carried out in food analysis laboratory, Department of Agricultural

Engineering and Food Technology, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut. The experimental setup and the methodology for the production of control, KMS (Potassium metabisulfite) and NaSHO4 (Sodium bisulfate) sample of the whole, fresh unripe banana. The best quality dried product will be stored under ambient storage conditions and packaging materials. Drying Characteristics in the form of Moisture content, Drying rate, Moisture ratio, and nutrition will be monitored at an interval of one month. All the experiments were conducted in food analysis laboratory in the Department of Agricultural Engineering and Food Technology. Fresh good quality banana of (unripe) was procured from the local market of Meerut. Care was taken to select firm and mature fruits without any defect in visual inspection. The selection of banana was unripe so as to get the best results and avoiding the further spoilage of the banana. The raw banana was peeled and cut into small pieces to the thickness of 8-12 mm. size and then dipped in the solution using tap water for 4 minutes and then rinsed by tap water in order to remove the rest of the chemical solution from the slice surface. During drying, the hot air oven temperatures, tray drying temperatures used will be 60°C, 70°C and 80°C and microwave oven temperatures used will be 40, 60 and 80W. During drying, the range of air velocity will be 0.8-1.0 m/s. Different pre-treatment methods have been developed for fruits drying, among which are lemon which are lemon juice, salt solution, honey dip, ascorbic acid, sulfuring, osmotic pre-treatment, and blanching (Karim, 2005). Pre-treatment usually performed between preparation and subsequent processing. The raw banana was peeled and cut into small pieces to the thickness of 8-12 mm. size and then dipped in the solution using tap water for 4 minutes and then rinsed by tap water in order to remove the rest of the chemical solution from the slice surface. Two chemicals solution is used in pre-treatment of banana chips was KMS (Potassium metabisulfite) 1%, NaSHO4 (Sodium bisulfate) 1%. One segment of the present study relates to drying. Before drying, some physical and chemical treatments will be given to the samples. Control samples will be also taken.

The study of drying behavior of different materials has been the subject of interest for various investigators on both theoretical and practical grounds. In the course of studies conducted regarding the drying behavior of various agricultural products. During drying, the hot air oven temperatures, tray drying temperatures used will be 60°C,70°C and 80°C, and microwave oven temperatures used will be 40, 60 and 80W. During drying, the range of air velocity will be 0.8-1.0 m/s.

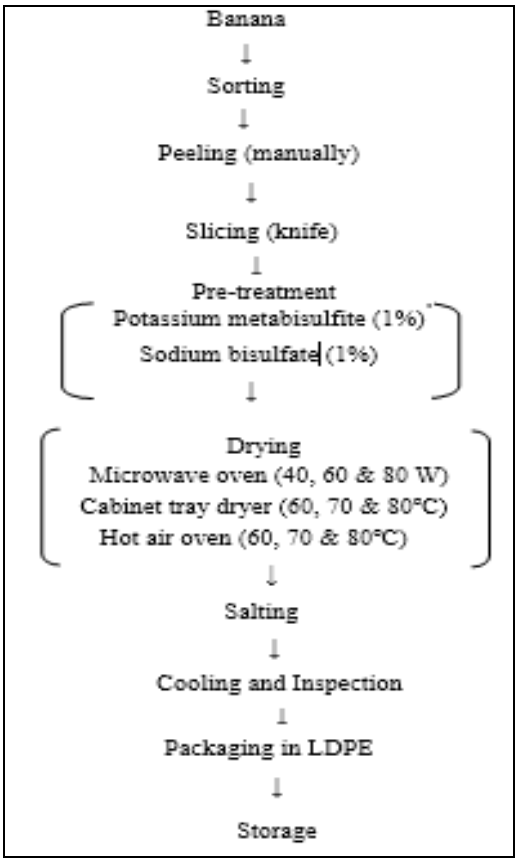

Fig 1: Flow Chart for Preparation of Banana chips

Results and discussion

Banana chips have become popular across different sections of populations both in urban and rural India. Among banana chips are the most popular because of various appealing factors and excellent storage qualities, besides universal availability. The results of the experiments conducted on the development and quality evaluation of banana chips during storage are presented in this chapter. Quality evaluation and sensory analysis were analyzed at different storage periods using standard procedures. The quality of the banana chips was evaluated on the basis of drying characteristics like moisture content, drying rate, moisture ratio.

Cabinet tray dryer

The change in moisture content of treated and controlled banana slice samples was calculated. The data for moisture content is given in Table(1–3) In general it was found that it took 210, 270, and 300 min in cabinet tray drying to reduce

the moisture content of banana slice at the constant level for all samples. The banana slice was dried at 60^0C, 70^0C, and 80^0C for intervals of 30 mins in a cabinet tray dryer to achieve the final moisture content. The drying time was longest at 60°C and least at 80°C in the tray drying. The moisture content was found highest in NaHSo4 treated as compared to controlled and KMS treated at 60°C. The moisture content was found highest in controlled as compared to KMS treated and NaHSo4 treated sample at 70^0C. And the moisture content was found highest in NaHSo4 treated as compared to KMS treated and controlled sample at 80°C. The drying times at 60^0C, 70^0C, and 80^0C in cabinet tray dryer were observed as 300, 270, and 210 min respectively. The variation in moisture content with drying time at different temperatures and different pre-treatment. There was the significant reduction in drying time with the increase in drying temperature. In cabinet tray drying with increasing temperature drying time decreased. This is in accordance to the kinetic theory that due to increasing in temperature, the energy of water molecules increases and hence, escaping of molecules becomes easier and faster from the medium, Prabhanjan *et al*., (1995) [5]. The moisture-time relationship was found non-linear and it was observed that the decrease in moisture is larger initially as compared to the later part of drying. There was a significant reduction in drying time with an increase in drying temperature. Similar behaviors were observed by Salgado *et al*., (1994) [8] for sugar beet root and sugar beet pulp, Maskan *et al*., (1998) [3] for mulberry. The drying rate was calculated by dividing the difference of two consecutive. The result of cabinet tray drying experiments showed that increasing of cabinet tray dryer temperature increased drying rate.

The trend of change in drying rate (g water /g dry matter-min) with moisture content (g water / g dry matter) for controlled (T0), KMS (T1) and $NaHSO_4$ (T2) banana slices at temperature 60^0C, 70^0C, and 80^0C. It was observed that drying rate was higher in the initial periods of drying and subsequently it reduced with a decrease in moisture content. Drying rates during drying of a banana slice at 600C were found 0.05, 0.11, and 0.06 for controlled, KMS treated, and NaHSO4 treated sample respectively. The mean drying rates during drying of banana slice were found at 0.02, 0.17 and 0.07 for controlled, KMS treated, and $NaHSO_4$ treated sample respectively at 70^0C. The drying rates during drying of banana slice were found 0.04, 0.09, and 0.06 for controlled, KMS treated, and $NaHSO_4$ treated sample respectively at 80^0C. Experimental results of cabinet tray dryer drying method showed that drying rate of treated samples was higher than controlled samples. This contributed to the effects of chemical treatments on structure damage of banana slice result moisture removal was easier than the control sample. The value of moisture content (% d.b.) and moisture ratio observed in the experiment at different temperatures and pre-treatments. The relation between moisture ratio and drying time, which clearly shows moisture ratio initially decreased very rapidly and in later stage moisture ratio decreased at a slower rate. The data, in general, showed that moisture ratio decreased continuously as drying progressed with the diffusion process slowing down.

Table1: Determination of moisture content, drying rate and moisture ratio in cabinet tray dryer at 60^0C& different pretreatment.T0 (Controlled) T1 (Potassium metabisulphite) T2 (Sodium bisulfate)

Drying Time (min)	mc(db)%	drying rate	Moisture ratio	Drying Time (mins	MC(db)%	Drying rate	Moisture ratio	Drying Time (min)	MC(db)%	Drying rate	Moisture ratio
0	346.4286		1	0	346.4286		1	0	346.4286		1
30	285.125	2.043452	0.810853	30	275.4464	2.366071	0.801629	30	281.25	2.172619	0.786289
60	231.9464	1.772619	0.646776	60	215.1786	2.008929	0.628641	60	224.4107	1.894643	0.604838
90	186.5	1.514881	0.506556	90	159.375	1.860119	0.48913	90	178.5714	1.527976	0.436827
120	151.375	1.170833	0.398182	120	114.2857	1.502976	0.373206	120	140.4821	1.269643	0.301075
150	118.2143	1.105357	0.295868	150	83.03571	1.041667	0.263913	150	104.5714	1.197024	0.206989
180	87.5	1.02381	0.201103	180	50	1.10119	0.162446	180	71.23214	1.11131	0.107527
210	60.53571	0.89881	0.117907	210	23.21429	0.89285	0.071794	210	41.4464	0.992857	0.026882
240	34.82143	0.457143	0.038569	240	18.75	0.14881	0.029892	240	27.67857	0.458929	0.013441
270	25.89286	0.197619	0.011021	270	16.07143	0.12286	0.005435	270	19.64286	0.167857	0.005376
300	22.32143	0.059524	0.0000	300	14.28571	0.11904	0.0000	300	17.85714	0.069524	0.0000

T0 (Controlledsample) T1 (Potassium metabisulphite) T2 (Sodium bisulfate)

Table 2: Determination of moisture content, drying rate and moisture ratio in cabinet tray dryer at 70^0C& different pretreatment. T0 (Controlled) T1 (Potassium metabisulphite) T2 (Sodium bisulfate)

Drying Time (min)	MC (db)%	Drying rate	Moisture ratio	Drying Time (min)	MC (db)%	Drying rate	Moisture ratio	Drying Time (min)	MC (db)%	Drying rate	Moisture ratio
0	346.4286		1	0	346.4286		1	0	346.4286		1
30	265.1786	2.708333	0.792746	30	275	2.380952	0.787108	30	277.0357	2.313095	0.753173
60	197.3214	2.261905	0.598239	60	213.3929	2.053571	0.603491	60	211.9107	2.170833	0.547032
90	150.8929	1.547619	0.413866	90	155.5536	1.927976	0.40342	90	150.1786	2.057738	0.39421
120	109.8214	1.369048	0.265227	120	113.1071	1.414881	0.24531	120	100.4107	1.658929	0.2342
150	71.01786	1.293452	0.1704	150	75	1.270238	0.15421	150	68.66071	1.058333	0.14321
180	34.82143	1.206548	0.095734	180	41.875	1.104167	0.092288	180	43.66071	0.833333	0.05338
210	22.21429	0.420238	0.051734	210	16.07143	0.860119	0.015381	210	28.92857	0.491071	0.015081
240	17.85714	0.145238	0.016	240	13.28571	0.292857	0.007079	240	16.96429	0.39881	0.001844
270	17.25	0.020238	0.0000	270	10.91071	0.178571	0.0000	270	11.60714	0.079167	0.0000

T0 (Controlledsample) T1 (Potassium metabisulphite) T2 (Sodium bisulfate)

Table 3: Determination of moisture content, drying rate and moisture ratio in cabinet tray dryer at 80^0C& different pretreatment.
T0 (Controlled) T1 (Potassium metabisulphite) T2 (Sodium bisulfate) at (80^0C)

Drying Time (min)	MC (db)	Drying rate	Moisture ratio	Drying Time (min)	MC (db)%	Drying rate	Moisture ratio	Drying Time (min)	MC (db)%	Drying rate	Moisture ratio
0	346.4286		1	0	346.4286		1	0	346.4286		1
30	255.7679	3.022024	0.741259	30	257.3571	2.969048	0.729774	30	255.7679	3.022024	0.679097
60	186.125	2.321429	0.4732	60	171.6429	2.857143	0.4034	60	186.125	2.321429	0.3829
90	132.5536	1.785714	0.362519	90	98.42857	2.440476	0.279593	90	132.5536	1.785714	0.130367
120	80.55357	1.733333	0.207527	120	32.94643	2.182738	0.089377	120	80.55357	1.733333	0.046798
150	30.35714	1.673214	0.057911	150	19.39286	0.786905	0.020801	150	30.35714	1.673214	0.020422
180	12.91071	0.281548	0.008092	180	10.64286	0.145833	0.00591	180	12.91071	0.581548	0.004701
210	10.92857	0.046071	0.0000	210	6.178571	0.092857	0.0000	210	10.92857	0.066071	0.0000

T0 (Controlledsample) T1 (Potassium metabisulphite) T2 (Sodium bisulfate)

Microwave oven

The data for moisture content is given in table (4to6). The initial moisture content prior to drying was observed 346.43% (d.b.). The variation in moisture content with drying time at different temperatures and different pre-treatments. It was observed that banana slice took 7,9, and 10 minutes to reduce the moisture content at the constant level for all samples in microwave oven drying. The banana slices were dried at 40, 60 and 80 watts for intervals of 1 min in a microwave oven to achieve the final moisture content. All samples took 10 mins to attained final moisture content at 40 watts the final moisture content was found with 22.04%, 15.08%, and 16.48% for controlled, KMS and NaSHO4 treated samples respectively. It was observed that all samples took 9 mins to attained final moisture content at 9.82%, 8.03%, and 9.92% for controlled, KMS, and NaSHO4 treated samples respectively at 60 watts. It was observed that all samples took 7 mins to attained final moisture content at 9.14%, 7.32%, and 9.10% for controlled, KMS, and NaSHO4 treated samples respectively at 80 watts. The drying times at 40, 60 and 80 watts were observed as 10, 9, and 7 mins respectively for all samples in the microwave oven. In microwave drying methods with increasing, microwave power intensity drying time was decreased. The results for drying methods showed that pretreatments caused shorter drying time relative to control samples. The reason may be due to the effects of chemical treatment KMS and NaSHO4 damaged cell wall of banana slice caused moisture removal was enhanced.

The drying rate was calculated by dividing the difference of two consecutive. Results of microwave drying method with increasing of microwave power intensity increased drying rate. The reasons are clear so increase of heat convection rate and more moisture evaporation from food material. It was found that change in drying rate (g water / g dry matter- min) with moisture content (g water / g dry matter) for controlled (T0), KMS (T1) and $NaHSO_4$ (T2) dried banana slices at temperature 40 watts, 60, and 80 watts. It was observed that drying rate was higher in the initial periods of drying and subsequently it reduced with a decrease in moisture content. Drying rates during drying of a banana slice at 40 watts were found 1.17, 1.98, and 1.96 for controlled, KMS treated, and NaHSO4 treated sample respectively. The mean drying rates during drying of banana slice were found 1.67, 4.07, and 2.91 for controlled, KMS treated, and $NaHSO_4$ treated sample respectively at 60 watts. The drying rates during drying of banana slice were found 3.76, 5.55, and 3.14 for controlled, KMS treated, and $NaHSO_4$ treated sample respectively at 80 watts. The drying method showed that the drying rate of treated samples was higher than the controlled samples. This contributed to the effects of chemical treatments on structure damage of banana slice result moisture removal was easier than the control sample. Experimental results of microwave drying method showed that drying rate was changed at different pretreatments at constant microwave power intensity, also it didn't obey from special trends. The relation between moisture ratio and drying time is given in table 4 to 6, which clearly shows moisture ratio initially decreased very rapidly and in later stage moisture ratio decreased at a slower rate.

Table 4: Determination of moisture content, drying rate and moisture ratio in Microwave oven at 40 watt& different pretreatment.
T0 (Controlled) T1 (Potassium metabisulphite) T2 (Sodium bisulfate)

Drying Time (min)	MC (db)%	Drying rate	Moisture ratio	Drying Time (min)	MC (db)	Drying rate	Moisture ratio	Drying Time (min)	MC (db)%	Drying rate%	Moisture ratio%
0	346.4286		1	0	346.429		1	0	346.429		1
1	259.339	87.0893	0.775396	1	264.696	81.7321	0.6932	1	272.321	74.1071	0.6546
2	203.804	55.5357	0.560323	2	198.429	66.2679	0.50321	2	202.679	69.6429	0.4986
3	155.768	48.0357	0.412242	3	136.321	62.1071	0.365885	3	150.446	52.2321	0.341
4	113.107	42.6607	0.28073	4	86.125	50.1964	0.21439	4	107.143	43.303	0.2087
5	75.1964	37.9107	0.163861	5	60.9286	25.1964	0.138346	5	65.1786	41.9643	0.1235
6	47.3214	27.875	0.086594	6	39.6964	21.2321	0.07793	6	45.0536	20.125	0.074266
7	36.5	10.8214	0.04457	7	28.7857	10.9107	0.032473	7	27.1964	17.8571	0.0235
8	29.4643	7.03571	0.022881	8	22.2321	6.55357	0.021558	8	22.625	4.57143	0.018618
9	23.2143	6.25	0.003614	9	17.0714	5.16071	0.009	9	18.4643	4.16071	0.006008
10	22.0429	1.17143	0.0000	10	15.0893	1.98214	0.0000	10	16.4821	1.96214	0.0000

T0 (Controlledsample) T1 (Potassium metabisulphite) T2 (Sodium bisulfate)

Table 5: Determination of moisture content, drying rate and moisture ratio in Microwave oven at 60 watt & different pretreatment. T0 (Controlled) T1 (Potassium metabisulphite) T2 (Sodium bisulfate)

Drying Time (min)	MC (db)%	Drying rate	Moisture ratio	Drying Time (min)	MC (db)%	Drying rate	Moisture ratio	Drying Time (min)	MC (db)%	Drying rate	Moisture ratio
0	346.4286		1	0	346.4286		1	0	346.429		1
1	255.3214	91.10714	0.771345	1	269.0536	77.375	0.735127	1	257.1429	89.28571	0.729336
2	168.2679	87.05357	0.575989	2	202.9464	66.10714	0.547067	2	193.75	63.39286	0.470716
3	91.875	76.39286	0.423271	3	151.2679	51.67857	0.376225	3	136.1607	57.58929	0.243766
4	59.73214	32.14286	0.274723	4	101	50.26786	0.266303	4	99.10714	37.05357	0.148276
5	38.89286	20.83929	0.160354	5	57	44	0.144696	5	63.39286	35.71429	0.086366
6	25.21429	13.67857	0.091222	6	31.41071	25.58929	0.069076	6	40.08929	23.30357	0.045729
7	17.07143	8.142857	0.033215	7	18.625	12.78571	0.031293	7	20.53571	19.55357	0.021539
8	13.89286	3.178571	0.012096	8	10.94643	7.678571	0.008602	8	11.60714	8.928571	0.006728
9	9.821429	1.67429	0.0000	9	8.035714	4.070714	0.0000	9	9.9286	2.917857	0.0000

T0 (Controlledsample) T1 (Potassium metabisulphite) T2 (Sodium bisulfate)

Table 6: Determination of moisture content, drying rate and moisture ratio in Microwave oven at 80 watt & different pretreatment. T0 (Controlled) T1 (Potassium metabisulphite) T2 (Sodiumbisulfate)

Drying Time (min)	MC (db)%	Drying rate	Moisture ratio	Drying Time (min)	MC (db)%	Drying rate	Moisture ratio	Drying Time (min)	MC (db)%	Drying rate	Moisture ratio
0	346.429		1	0	346.429		1	0	346.429		1
1	254.464	91.9643	0.7536	1	256.357	90.07143	0.735969	1	257.375	89.0536	0.725567
2	179.464	75	0.514749	2	179.571	76.78571	0.4952	2	175.804	81.5714	0.4754
3	116.482	62.9821	0.343062	3	120.5357	59.03571	0.313812	3	107.946	67.85714	0.292937
4	56.5357	59.9464	0.197653	4	70.5357	50	0.142313	4	57.1429	50.8036	0.1267
5	30.7679	25.7679	0.073017	5	27.6786	42.85714	0.05803	5	20.5357	36.6071	0.033778
6	15.0893	15.6786	0.015248	6	16.4429	23.21429	0.011244	6	14.2857	6.25	0.005506
7	9.1424	3.76786	0.0000	7	7.32143	5.552857	0.0000	7	9.10286	3.14286	0.0000

T0 (Controlledsample) T1 (Potassium metabisulphite) T2 (Sodium bisulfate)

Hot air oven

The data for moisture content is given in table (7 to 9). The initial moisture content prior to drying was observed 346.43% (d.b.). The variation in moisture content with drying time at different temperatures and different pre-treatments. It was observed that banana slice took 180, 270, and 300 minutes to reduce the moisture content at a constant level for all samples in hot air oven drying. The banana slices were dried at 60^0C, 70^0C, and 80^0C for intervals of 30 mins in a hot air oven to achieve the final moisture content. All samples took 300 mins to attained final moisture content at 60^0C the final moisture content was found at 15.87%, 8.92%, and 13.39% for controlled, KMS and $NaSHO_4$treated samples respectively. It was observed that all samples took 270 mins to attained final moisture content 10.91%, 7.12%, and 12.50% for controlled, KMS, and $NaSHO_4$ treated samples respectively at 700C. It was observed that all samples took 180 mins to attained final moisture content 10.46%, 7.02%, and 9.92% for controlled, KMS, and $NaSHO_4$ treated samples respectively at 800C. The drying times at 60^0C, 70^0C, and 80°C were observed at 300, 270, 180 mins respectively for all samples in a hot air oven. In hot air oven drying with increasing temperature drying time decreased. The results for drying methods showed that pretreatments caused shorter drying time relative to control samples. The reason may be due to the effects of chemical treatment KMS and $NaSHO_4$ damaged cell wall of banana slice caused moisture removal was enhanced. There was the significant reduction in drying time with an increase in drying temperature. This is in accordance to a kinetic theory that due to increasing in temperature, the energy of water molecules increases and hence, escaping of molecules becomes easier and faster from the medium, Prabhanjan *et al*., (1995) [5]. The drying rate was calculated by dividing the difference of two consecutive. The result of hot air oven drying experiments showed that increasing of hot air temperature increased drying rate. It was found that change in drying rate (g water / g dry matter- min) with moisture content (g water / g dry matter) for controlled (T0), KMS (T1) and $NaHSO_4$ (T2) banana slices at temperature 60^0C, 70^0C, and 80^0C. It was observed that drying rate was higher in the initial periods of drying and subsequently it reduced with a decrease in moisture content. Drying rates during drying of a banana slice at 60^0C were found 0.05, 0.09, and 0.08 for controlled, KMS treated, and $NaHSO_4$ treated sample respectively. The mean drying rates during drying of banana slice were found at 0.03, 0.14 and 0.05 for controlled, KMS treated, and $NaHSO_4$ treated sample respectively at 70^0C. The drying rates during drying of banana slice were found 0.66, 1.06, and 0.69 for controlled, KMS treated, and $NaHSO_4$ treated sample respectively at 80^0C. Experimental results of hot air oven drying method showed that drying rate of treated samples was higher than controlled samples. The relation between moisture ratio and drying, which clearly shows moisture ratio initially decreased very rapidly and in later stage moisture ratio decreased at a slower rate.

Table 7: Determination of moisture content, drying rate and moisture ratio in Hot air oven at 60^0C& different pretreatment.
T0 (controlled) T1 (Potassium metabisulphite) T2 (Sodium metabisulfate)

Drying Time (min)	MC (db)%	Drying rate	Moisture ratio	Drying Time (min)	MC (db)%	Drying rate	Moisture ratio	Drying Time (min)	MC (db)%	Drying rate	Moisture ratio
0	346.4286		1	0	346.4286		1	0	346.4286		1
30	265.2857	2.704762	0.754523	30	259.7321	2.889881	0.74388	30	256.3571	3.002381	0.729544
60	186.5179	2.625595	0.516233	60	179.375	2.678571	0.506488	60	168.0714	2.942857	0.464451
90	114.5	2.400595	0.298363	90	110.125	2.308333	0.2864	90	92.26786	2.526786	0.236838
120	79.96429	1.15119	0.193884	120	53.57143	1.885119	0.134839	120	60.92857	1.044643	0.1238
150	58.53571	0.714286	0.129058	150	36.67857	0.563095	0.084934	150	42.85714	0.602381	0.0787
180	36.51786	0.733929	0.062449	180	25.21429	0.382143	0.051066	180	26.98214	0.529167	0.040807
210	24.10714	0.41369	0.024904	210	17.46429	0.258333	0.0237	210	22.42857	0.151786	0.0228
240	20.53571	0.119048	0.0141	240	13.07143	0.146429	0.0138	240	18.07143	0.145238	0.0136
270	17.46429	0.102381	0.004808	270	10.69643	0.079167	0.0042	270	14.53571	0.117857	0.003434
300	15.875	0.052976	0.0000	300	8.928571	0.092262	0.0000	300	13.39286	0.088095	0.0000

T0 (Controlledsample) T1 (Potassium metabisulphite) T2 (Sodium bisulfate)

Table 8: Determination of moisture content, drying rate and moisture ratio in Hot air oven at 70^0C& different pretreatment.
T0 (controlled) T1 (Potassium metabisulphite) T2 (Sodium metabisulfate)

Drying Time (min)	MC (db)%	Drying rate	Moisture ratio	Drying Time (min)	MC (db)%	Drying rate	Moisture ratio	Drying Time (min)	MC (db)%	Drying rate	Moisture ratio
0	346.4286		1	0	346.4286		1	0	346.4286		1
30	265.1786	2.708333	0.773796	30	258.9286	2.916667	0.741424	30	270.8929	2.517857	0.7241
60	197.3214	2.261905	0.554973	60	180.3214	2.620238	0.509129	60	197.8214	2.435714	0.4955
90	138.1607	1.972024	0.394545	90	120.0536	2.008929	0.331029	90	144.25	1.785714	0.2931
120	98.625	1.317857	0.281657	120	80.76786	1.309524	0.261431	120	106.5536	1.256548	0.214934
150	60.71429	1.26369	0.174117	150	42.85714	1.26369	0.14844	150	70.64286	1.197024	0.102902
180	34.82143	0.863095	0.090909	180	25.89286	0.565476	0.071267	180	42.85714	0.92619	0.05277
210	22.32143	0.416667	0.049198	210	13.39286	0.416667	0.034011	210	28.92857	0.464286	0.015831
240	13.39286	0.297619	0.013369	240	9.821429	0.239048	0.0074	240	16.96429	0.39881	0.005277
270	10.91071	0.032738	0.0000	270	7.12	0.14881	0.0000	270	12.5	0.05952	0.0000

T0 (Controlledsample) T1 (Potassium metabisulphite) T2 (Sodium bisulfate)

Table 9: Determination of moisture content, drying rate and moisture ratio in Hot air oven at 80^0C& different pretreatment.
T0 (controlled) T1 (Potassium metabisulphite) T2 (Sodium metabisulfate)

Drying Time (min)	MC (db)%	Drying rate	Moisture ratio	Drying Time (min)	MC (db)%	Drying rate	Moisture ratio	Drying Time (min)	MC (db)%	Drying rate	Moisture ratio
0	346.4286		1	0	346.4286		1	0	346.4286		1
30	204.4643	2.843452	0.753654	30	263.0893	2.777976	0.739672	30	261.125	2.843452	0.584856
60	132.3929	2.477381	0.527949	60	186.7321	2.545238	0.51286	60	186.8036	2.477381	0.374099
90	73.21429	2.404167	0.314489	90	104.5179	2.407143	0.292752	90	114.6786	2.404167	0.201044
120	22.32143	1.752381	0.200316	120	65.89286	1.2875	0.132316	120	62.10714	1.752381	0.052219
150	12.46714	0.777976	0.094748	150	20.17857	1.190476	0.06109	150	28.76786	0.777976	0.010444
180	10.4646	0.667262	0.0000	180	7.025	1.068452	0.0000	180	9.92	0.697262	0.0000

T0 (Controlledsample) T1 (Potassium metabisulphite) T2 (Sodium bisulfate)

Conclusion

The moisture content was decreased with increase in temperature. The moisture content of KMS treated banana slice was found to be lowest in cabinet tray dryer at 80^0C. Among the hot air oven and microwave oven drying respective of pre-treatment. KMS treated banana slice took minimum time to get the final moisture content within 7 min of microwave oven drying at 80 watts. Constant rate of drying was absent throughout the process. Drying rate was found superior for KMS treated banana slices in a microwave oven at 80 watts as compared $NaHSO_4$ treated and controlled banana slice. The drying rate of KMS treated banana slices was found to be highest in cabinet tray dryer at 70^0C as compared to $NaHSO_4$ treated and controlled banana slice. Drying rate was found to be highest for KMS treated banana slices dried in hot air oven at 800C as compared to $NaHSO_4$ treated and controlled banana slice. Major drying took place in the falling rate period. Moisture ratio initially decreased very rapidly and in a later stage decreased at a slower rate. $NaHSO_4$ treated banana chips gain the least moisture as compared to KMS treated and controlled banana chips after 45 days of storage dried at 80^0C in a hot air oven. Controlled banana chips gain the highest Moisture dried at 60^0C in hot air oven after 45 days of storage period. Thus from present studies, it can be concluded that the banana chips pre-treated with KMS solution dried in cabinet tray dried at (80^0C) and microwave oven at (80 watts) exhibited best results over the drying methods. Another pre-treatment i.e. of the $NaHSO_4$ solution and drying method i.e. hot air oven drying was also found to be good during this present study. Therefore, the above pre-treatment and drying method could be recommended for drying of banana slices.

References

1. Robinson AA. Research Design and Development of banana dehydration process: Journal of food engineering. 1980; 3:255-260.
2. Bloem BR, Hausdor ff JM, Visser JE, Giladi N. Falls and Freezing of gait in Parkinson's disease: A review of two interconnected, prosodic phenomena. Mov Disord. 2004; 19:871-884.
3. Maskan M, Gogers F. Sorption isotherms and drying

characteristics of mulberry: Journal of Food Engineering. 1998; 37:437-449.
4. Nimsung P, Thongngam M, Naivikul O. Compositions, morphological and thermal properties of green banana flour and starch, a case study of unripe banana consists mainly of starch Kasetsart J. 2007; 41:324-330.
5. Prabhanjan DG, Ramaswamy HS, Raghavan GSV. Microwave-assisted Convective Air Drying of Thin Layer carrots: Journal of Food Engineering. 1995; 25:283-293.
6. Pekka MK, Nowakunda WK, Tushemereirwe C, Nankinga J, Namaganda, Kalyebara R. Farmer evaluation of banana based products. Afr. Crops Science. Journal. 2004; 12:27-31.
7. Singh HP, Uma S. Genetic diversity of banana in India. In: Proceedings of the Conference on "Challenges for Banana Production and Utilization in 21st Century," Trichy, Sept, 1996, 24-25.
8. Salgade MA, Lebert A, Gareia HS, Bimbenet JJ. Drying of sugar beet pulp using a laboratory air dryer: a case study of banana drying, Drying Technology. 1994; 12:955- 963.
9. Vijayakumar L. Suicide in India in Suicide in Asia. Yip PS, editor. Hong Kong Univ Press, 2008, 121-31.