

OSMO-AIR DRYING OF PINEAPPLE SLICES

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ABSTRACT

Osmotic dehydrated pineapple slices (3 mm thick) were prepared by immersing at 6, 9 and 12h in 60⁰Brix sugar solutions. Osmotically dehydrated pineapple were dried at 50, 60, 70⁰C air temperatures and 6.4 m/s air velocity using fluidized bed dryer to 5 to 8 % (db) moisture content. The quality of the powder was evaluated on the basis of physical, bio-chemical and organoleptic parameters. Increased in immersion time and drying temperature decreased the drying time. The maximum and minimum values of drying time were obtained 18 and 8 hours for T₁S₁ (50⁰C, 6h) and T₃S₃ (70 C, 12h) treatment, respectively. The powder prepared by treatment T₁S₁ contained maximum amount of ascorbic acid (43.35 mg), minimum solid gain (9.17 %) and maximum solubility (84.37 %). However, maximum amount of total sugar (66.80 %), reducing sugar (10.18 %) and titrable acidity (1.33 %) was found in the powder prepared by treatment T₃S₃. However, highest sensory score of the powder was obtained in T₂S₃ (60⁰C, 12h) treatment followed by T₁S₁ treatment. Considering all the physical, biochemical and organoleptic parameters T₁S₁ treatment was found to be best among all treatments.

KEY WORDS: *Fluidized bed drying, osmotic dehydration, pineapple, powder*

INTRODUCTION

The major pineapple growing countries in the world are Brazil, Thailand, Philippines, Costa Rica, China and India.² Assam has the maximum area for the cultivation of pineapple crop in India with medium productivity scale. This area can be used for more production of this crop resulting in more fibre opportunities. The region produces more than 40% of the total Pineapple of the country and almost 90-95% of the produce is organic (Kannojiya *et al.*, 2013). During 2013-14, India produced 1737 thousand tonnes of pineapple from

about 110 thousand hectares area (Anonymous, 2015).

Pineapple is a rich source of Vitamin C as well as other vitamins and fiber. Pineapple's bromelain stimulates digestion and the proper performance of the small intestine and kidneys; it helps in detoxification, normalizes colonic flora, helps in hemorrhoid alleviation and prevents and corrects constipation. It has been used to heal colds, mouth, throat and bronchial infections (Chaudhari *et al.*, 1993). Cooked peel cleans blood and alleviates swellings. Juice helps to cure cystitis and fevers. The world trade for

fresh and processed fruit represents 11% and 32 % of the total production.

Presently, the preparation of pineapple powder in the world is mainly done by spray drying or freeze drying, which are very expensive methods. There is a little work available on dehydration of pineapple using low cost air convection drying methods such as tray drying, fluidized bed drying, etc. There is a need to establish a low cost drying method instead of using high cost mechanical dryers. A novel concept of osmotic dehydration prior to hot air drying on pineapple slices will be introduced for better quality and consistent final dried product. This process will help in reducing the water content, increasing shelf life and increasing soluble solid content of the fruit. Also, this process is very useful to maintain the original colour, flavour, odour, texture and aroma of the dried product. As far as previous findings on drying of pineapple are concerned, there is no attempt was made on drying of pineapple using fluidized bed dryer. So, the present investigation was carried out looking into these demands.

MATERIALS AND METHODS

The experiment on preparation of pineapple powder was carried out at the Department of Agricultural Process Engineering, College of Agricultural Engineering and Technology, Junagadh Agricultural University, Junagadh.

Moisture content

The initial moisture content of the fresh as well as osmosed pineapple slices at different stages during the experiment was determined by hot air oven method at the temperature of $100 \pm 2^{\circ}\text{C}$ for 18 h (Ranganna, 2000).

Experimental procedure

Ripe and firm pineapple fruits of queen variety were peeled (skin, eyes, crown), sliced (3 mm thick) and cored out (central hard portion) by

using sharp knife. Then pineapple slices washed with fresh water to remove surface dusts or any other impurities. The physical properties like moisture content, fruit weight, maximum and minimum diameter of whole fruit, length of whole fruit, length to diameter ratio and pulp to peel ratio were determined.

Osmotic dehydration of pineapple slices

The sugar solution for osmotic dehydration was prepared by adding 1400-1500 g of sugar in one liter of water in a stainless steel vessel. The solution was gently boiled and stirred on a stove till desired 60°Brix solution obtained. The concentration of solution was measured by hand refractometer. Pineapple slices were immersed in a glass jar containing 60°Brix sugar solutions. The ratio of fruit to sugar solution was kept 1:4. These jars were stored at room temperature for different immersion times (6, 9 or 12 hrs).

After the completion of immersion time, the slices were removed from the jar and washed with fresh water to remove stickiness from the slices. These slices were then put on a blotting paper to remove surface moisture and stickiness from the slices. The slices were put on this blotting paper for 5 to 10 minutes by altering both the sides of the slices. A sample of slice was then taken for the moisture content determination. The observations of water loss, solid gain and final moisture contents were recorded as per standard methods.

Fluidized bed drying of osmotically dehydrated pineapple slices

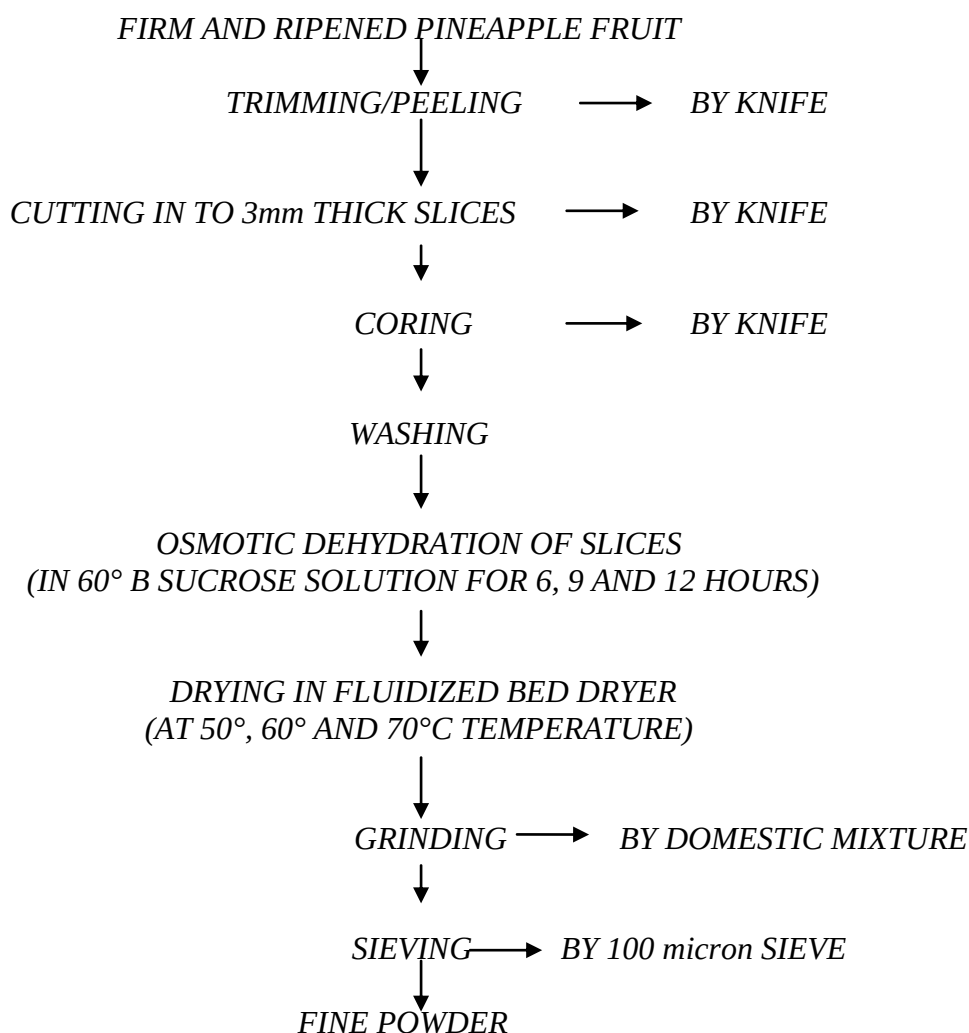
The osmotically dehydrated slices of 3 mm thickness were loaded in the fluidized bed dryer (Figure 1) with 3 layers, hence making bed thickness of 9 mm in the fluidized bed dryer. The drying was carried out at 3

different drying air temperatures i.e. 50°, 60° and 70°C and at a constant air velocity of 6.4 m/s. The observations of weight of slices, moisture content, drying rates were recorded at each hour during drying of osmotically dehydrated pineapple slices. The drying was carried out continuously until desired moisture content (5 to 8 % (db)). After drying at desired moisture content, the dried samples were taken out and placed in the

desiccators. Dried pineapple slices obtained after the fluidized bed drying were then grinded by using electric mixer and the prepared powder was sieved by using 100 micron sieve. The fine powder was then packed in a polythene bag and stored at room temperature. The quality of the powder was determined on the basis of following parameters by standard methods (Sadasivam and Manickam, 1996).

- Physical parameter** : Recovery, solubility and bulk density
Biochemical parameter : Total sugar, reducing sugar, titrable acidity and ascorbic acid
Organoleptic parameter : Appearance, odour, flavour, colour, taste and over all acceptability

PROCESS FLOW CHART FOR MAKING PINEAPPLE POWDER





Preparation of sugar syrup



Osmotic dehydration of slices



Osmosed pineapple slices



Removal of surface moisture



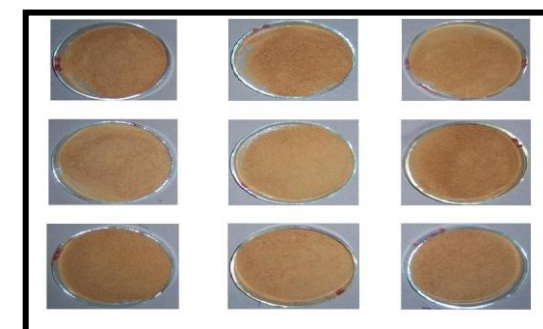
Fluidized bed drying of pineapple slices



Fluidized bed dryer



Dried pineapple slices



Dried pineapple powder of 9 treatment

Plate 1: Osmo-air drying of pineapple slices

RESULTS AND DISCUSSION

The observations of physical properties of fresh pineapple fruits, osmotic dehydration of pineapple slices, fluidized bed drying of osmosed pineapple slices and various physical, biochemical and organoleptic parameters of the pineapple powder were recorded.

Physical properties of pineapple fruit

The physical properties like moisture content, fruit weight, maximum and minimum diameter of whole fruit, length of whole fruit, length to diameter ratio and pulp to peel ratio were determined as per standard methods (Table 1).

Osmotic dehydration of fresh pineapple slices

Mass transport during osmosis

The mass transport during osmotic dehydration in terms of solid gain, weight loss and water loss in percentage was determined. The values of solid gain, weight loss and water loss at 6, 9 and 12 h immersion time in 60⁰ Brix sugar solutions at ambient temperature were given in Table 2.

Effect of immersion time on solid gain

The maximum value of solid gain was observed as 15.73 % for 12 hour immersion time. Minimum value of solid gain was observed as 9.17 % for 6 hour immersion time. It showed that as immersion time increased, the value of solid gain also increased. The values of solid gain shown in Table 2 are mean values of replications. Statistical analysis of solid gain data with CRD showed that value of solid gain is significant. The results obtained are in accordance with the results of Saputra (2001), who studied the effects of sugar type, sugar concentration, immersion time and temperature on the mass transfer of osmotic dehydration,

using pie shape slices (7 mm thick) of fresh pineapple.

Although, the similar trend had also been observed in case of water loss, however the solid gain was much less than that of water loss. This trend was obvious, as the size of sugar molecules are larger than that of water and therefore, it was somewhat difficult for sugar molecules to penetrate into the pineapple slices.

Effect of immersion time on weight loss

In general, it was observed that the weight loss in pineapple slices was slightly decreasing with the increase in immersion time for all treatments, as shown in Table 2. The maximum weight loss was observed in 25.62 % for 6 h immersion time. The minimum weight loss was observed in 12 h immersion time, which was 24.72 %. Hence, the results revealed that the weight loss decreased with increased in immersion time. However, the rate of reduction in weight loss was very low and hence, found to be non significant.

Effect of immersion time on water loss

The water loss increased with the increase in immersion time. The maximum and minimum water loss was observed 40.45 and 34.69 %, for 12 and 6 h immersion time, respectively. Statistical analysis of water loss showed that the results for the water loss are significant. Similar kinds of results were obtained by Saputra (2001).

Fluidized bed drying of osmotically dehydrated pineapple slices

Initial moisture content of osmotically dehydrated pineapple slices

The initial moisture content of osmotically dehydrated pineapple slices was determined by hot air oven method as reported by Ranganna

(2000) and it was varying from 209.716 to 328.00 % (db).

Fluidized bed drying

The drying of osmotically dehydrated pineapple slices (6, 9 and 12 h immersion time) was carried out on fluidized bed dryer at different drying air temperature (50, 60 and 70⁰ C) and constant air velocity (6.4 m/s). The bed thickness of the osmotically dehydrated pineapple slices was kept 9 mm. The values of moisture content, drying rates and moisture ratios under different drying conditions were recorded.

Drying characteristics of osmotically dehydrated pineapple slices

The drying curves i.e., moisture content versus drying time at different immersion time and temperature were as shown in Figure 2.

Effect of drying time on moisture content

It was observed that the rate of moisture removal was very fast during initial two to three hours for all the 9 treatments. The rate of moisture removal was decreased with increase in drying time. All the drying was done in falling rate region. At later stage, it was observed that there was no reduction in moisture content with increase in drying time i.e., value of moisture content was considered as equilibrium moisture content (EMC).

Effect of drying air temperature on drying time

It was observed that at constant immersion time, increase in drying air temperature decreased drying time. At 6 h immersion time, the values of drying time for 50, 60 and 70⁰ C air temperature were 18, 14 and 11 hours, respectively. This indicated that at higher temperature (70⁰ C), the water vapour pressure inside the osmotically dehydrated pineapple slices increased rapidly and moisture evaporated more quickly than other lower temperature

ranges. Similar kind of trends was obtained at 9 and 12 h immersion time. Overall treatments data revealed that maximum and minimum values of drying times was 18 and 8 hours obtained in treatment T₁S₁ and T₃S₃, respectively.

Effect of immersion time on drying time

It was observed that at constant drying air temperature, increased in immersion time decreased the drying time (Figure 3). The results revealed that if the immersion time was increased then drying time decreased. The maximum and minimum drying time was obtained in treatment T₃S₃ and T₁S₁. At 50⁰ C drying air temperature, the values of drying time for 6, 9 and 12 h immersion time were 18, 15 and 13 hours, respectively. This indicated that at higher immersion time (12 h), the water loss of pineapple slices was more and internal cell membrane structure would become more porous, so moisture evaporated more quickly than other lower immersion times. Similar kind of trends was obtained at 60 and 70⁰ C drying air temperature. The results revealed that maximum and minimum values of drying times was 18 and 8 hours obtained in treatment T₁S₁ and T₃S₃, respectively. It was also observed that immersion time showed their effects on final moisture content of pineapple slices after osmotic dehydration. As the time of immersion increases, final moisture content after osmotic dehydration will decrease. Maximum and minimum moisture content after osmotic dehydration were 327.99 and 209.71 % (db) obtained in T₁S₁ and T₃S₃ treatments, respectively.

Quality evaluation of pineapple powder

The quality of the pineapple powder was evaluated on the basis of

physical, bio-chemical and organoleptic parameters.

Physical parameters

The bulk density, recovery and solubility of the pineapple powder samples prepared by different treatments were measured and are given in Table 3.

Bulk density

The values of bulk densities were ranging from 0.714 gm/cc to 0.761 gm/cc. The effect of immersion time and drying temperature on bulk density of pineapple powder was negligible.

Recovery

Recovery of the pineapple powder determines the quantity of powder obtained from the fruit. Recovery of pineapple powder decreased with increase in drying temperature. However, the value of recovery increased with the increase in immersion time. The maximum and minimum value of recovery was obtained 9.17 and 6.17 % for treatment T_1S_3 and T_3S_1 , respectively.

Solubility (WSI)

The solubility of pineapple powder was decreased with increase in temperature. However, effect of immersion time on solubility was minor; it slightly decreased with increase in immersion time. Maximum and minimum value of solubility was 84.37 and 64.13 % for treatment T_1S_1 and T_3S_3 , respectively.

Biochemical parameters

The total sugar, reducing sugar, titrable acidity and ascorbic acid of the pineapple powder samples prepared by different treatments were measured (Table 4).

Total sugar, reducing Sugar and titrable acidity

Total sugar of the pineapple powder increased with the increased in the immersion time. Total sugar of the powder was subsequently increased

52.06, 55.40 and 57.99 % for 6, 9 and 12 h immersion time, respectively for 50° C drying temperature and similar kind of trend was observed for 60°C and 70°C drying air temperature. Total sugar of the powder also increased with the increased in the drying temperature. The values of total sugar was lower (52.06 %) at lower temperature treatment T_1S_1 (50°C) and increased with increased in temperature i.e., 57.81 % at T_2S_1 (60°C) and 62.18 % for T_3S_1 (70°C). Minimum value of the total sugar obtained was 52.06 % for 6h immersion time and 50° C temperature (T_1S_1). Maximum total sugar obtained was 66.80 % for 12 h immersion time and 70°C temperature (T_3S_3). It indicated that more retention of total sugar was obtained in T_3S_3 treatment (Table 4). Similar kind of effects of immersion time and drying temperature were observed in reducing sugar and titrable acidity of pineapple powder.

Organoleptic evaluation

Organoleptic evaluation in terms of colour, odour, flavour, taste, appearance and overall acceptability of pineapple powder was done by the panel of experts using 9 point hedonic taste. The sensory evaluation of pineapple powder revealed that T_2S_3 treatment was found to be best, followed by treatment T_1S_1 , among all the treatments

CONCLUSION

The moisture contents of the osmotically dehydrated pineapple slices were decreased with increased in immersion time of pineapple slices in 60°Brix sugar solutions. Increased in immersion time and drying temperature had significantly reduced the drying time. The maximum and minimum values of drying time were obtained 18 and 8 hours for T_1S_1 (50°C, 6h) and T_3S_3 (70° C, 12h) treatment, respectively. The powder prepared by treatment T_1S_1 contents maximum amount of ascorbic acid

(43.35 mg), minimum solid gain (9.17 %) and maximum solubility (84.37 %). However, maximum amount of total sugar (66.80 %), reducing sugar (10.18 %) and titrable acidity (1.33 %) was found in the powder prepared by treatment T₃S₃. However, highest sensory score of the powder was obtained in T₂S₃ (60⁰ C, 12h) treatment, followed by T₁S₁ treatment. Considering all the physical, biochemical and organoleptic parameters T₁S₁ treatment was found to be best among all treatments.

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Table 1: Physical properties of fresh pineapple fruits

Sr. No.	Particulars	Value
1	Initial moisture content	84.90 to 88.1 % (wb) (i.e. 562.25 to 740.33 % (db))
2	Whole Fruit Weight	1300 to 1600 grams
3	Length of fruit	150 to 175 mm
4	Maximum Diameter	100 to 120 mm
5	Minimum Diameter	80 to 90 mm
6	Length to diameter ratio	1.81 to 2.38
7	Pulp to Peel Ratio	0.83 to 1.31

Table 2: Effect of different immersion time on solid gain, water loss and Weight Loss

Sr. No.	Treatments	Solid Gain (%)	Weight Loss (%)	Water Loss (%)
1	S ₁ (6 h)	9.17	25.62	34.69
2	S ₂ (9 h)	13.49	25.12	38.61
3	S ₃ (12 h)	15.73	24.72	40.45
	SEm	0.58	0.58	0.58
	CD at 5%	2.00	NS	2.00
	CV%	7.81	3.98	2.64

Table 3: Various physical parameters of pineapple powder

Sr. No.	Treatments	Bulk Density (gm/cc)	Recovery (%)	Solubility (%)
1	T ₁ S ₁	0.752	7.124	84.37
2	T ₁ S ₂	0.726	8.572	83.54
3	T ₁ S ₃	0.714	9.173	82.87
4	T ₂ S ₁	0.761	6.971	78.19
5	T ₂ S ₂	0.730	7.942	77.67
6	T ₂ S ₃	0.721	8.767	75.98
7	T ₃ S ₁	0.755	6.171	66.48
8	T ₃ S ₂	0.727	7.278	65.81
9	T ₃ S ₃	0.718	8.047	64.13

Table 4 : Various biochemical parameters of pineapple powder

Sr. No.	Treatments	Total Sugar (%)	Reducing Sugar (%)	Titration Acidity (%)	Ascorbic Acid (mg/100 g)
1	T ₁ S ₁	52.06	7.38	0.84	43.35
2	T ₁ S ₂	55.40	7.67	0.90	43.06
3	T ₁ S ₃	57.99	7.74	0.91	42.21
4	T ₂ S ₁	57.81	8.02	0.93	39.66
5	T ₂ S ₂	60.22	8.20	0.98	39.34
6	T ₂ S ₃	61.82	8.77	1.00	37.78
7	T ₃ S ₁	62.18	9.42	1.07	35.17
8	T ₃ S ₂	63.90	10.01	1.15	33.75
9	T ₃ S ₃	66.80	10.18	1.33	33.09
	SEm	0.50	0.19	0.04	0.48
	CD at 5%	1.48	0.57	0.11	1.42
	CV%	1.44	3.88	6.57	2.14

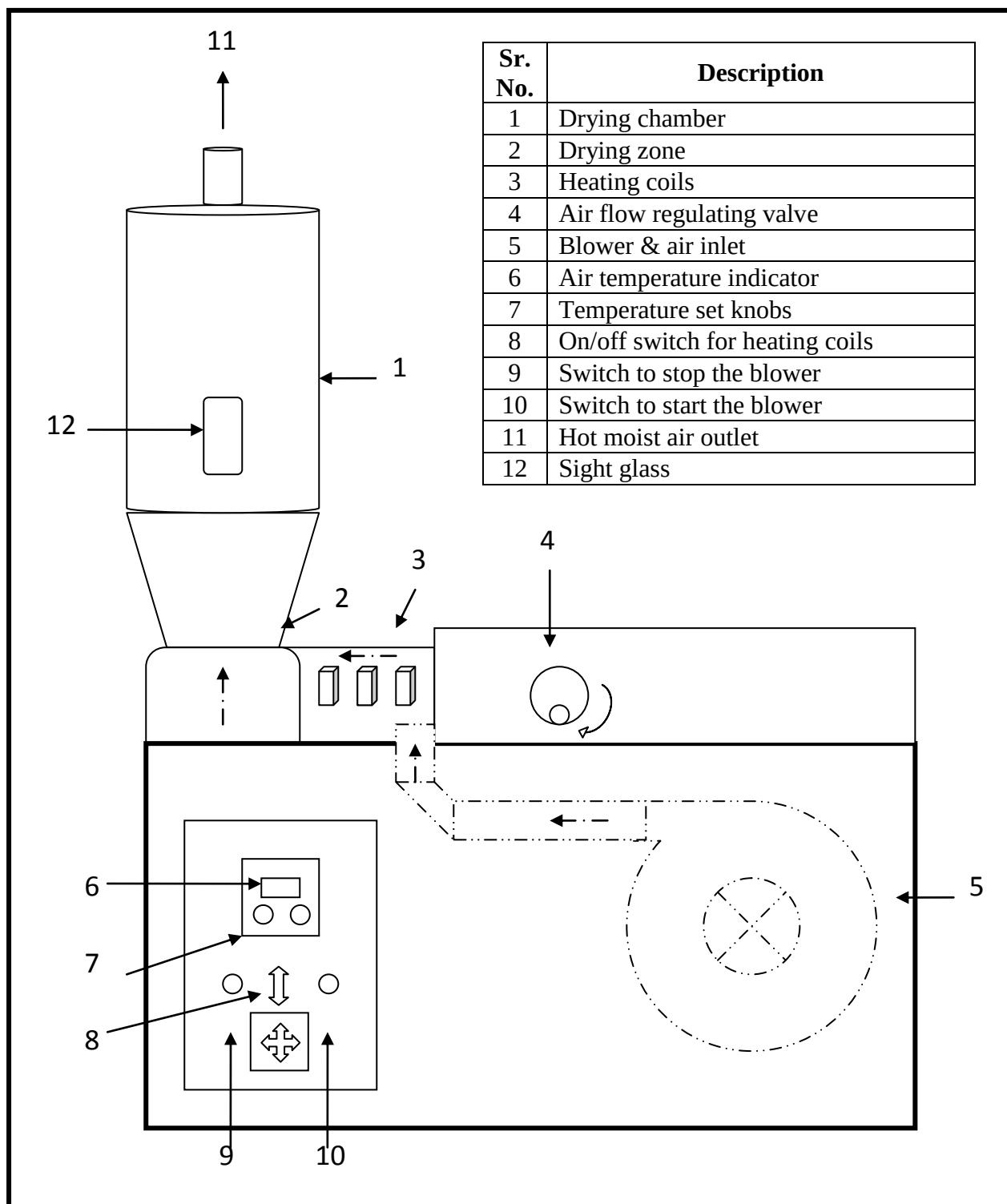


Figure 1: Schematic View of Fluidized Bed Dryer (Model Tabletop Cgmp Model "Powerpack")

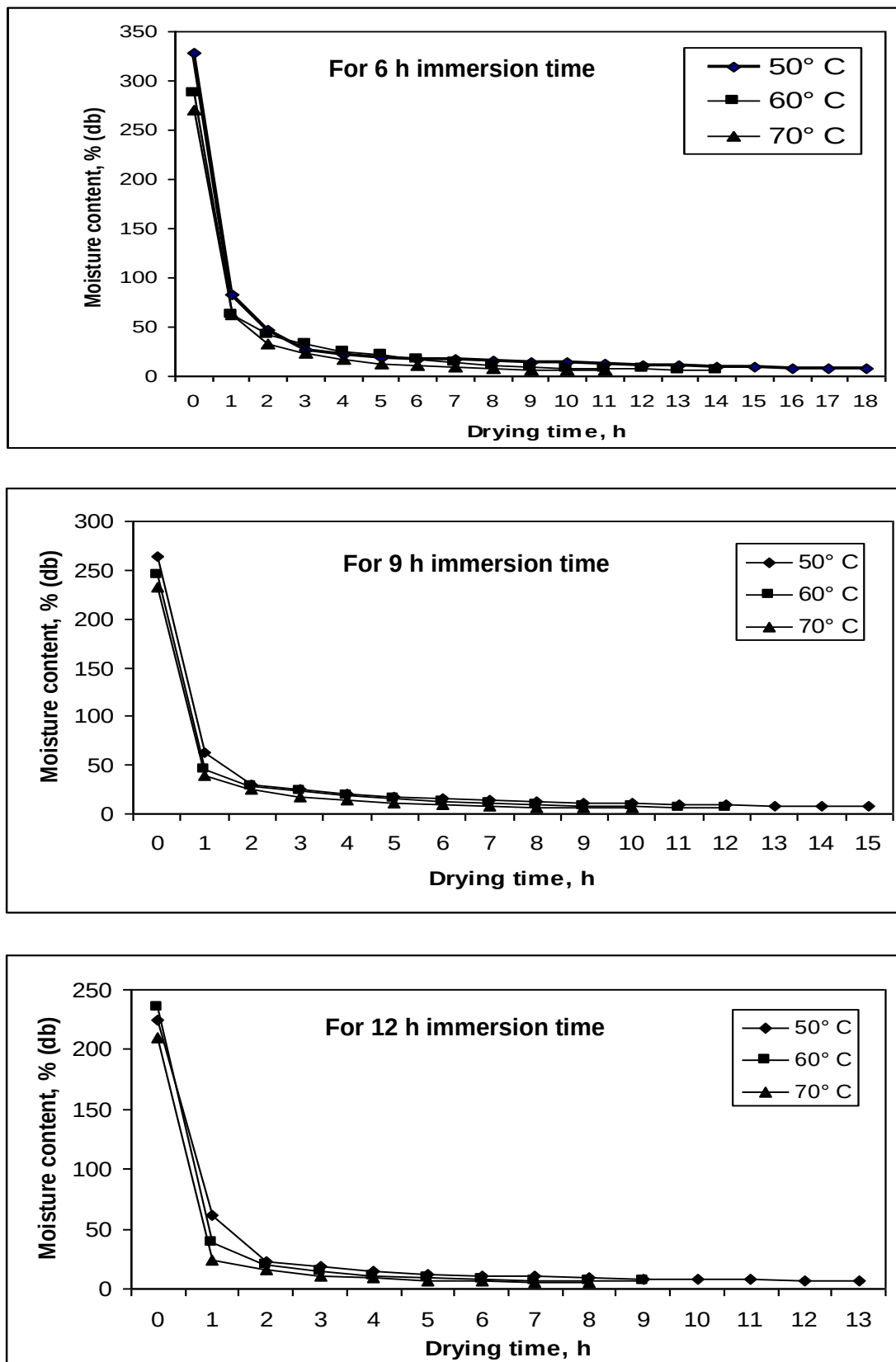


Figure 2: Relationship Between Moisture Content and Drying Time at Different Air Temperature

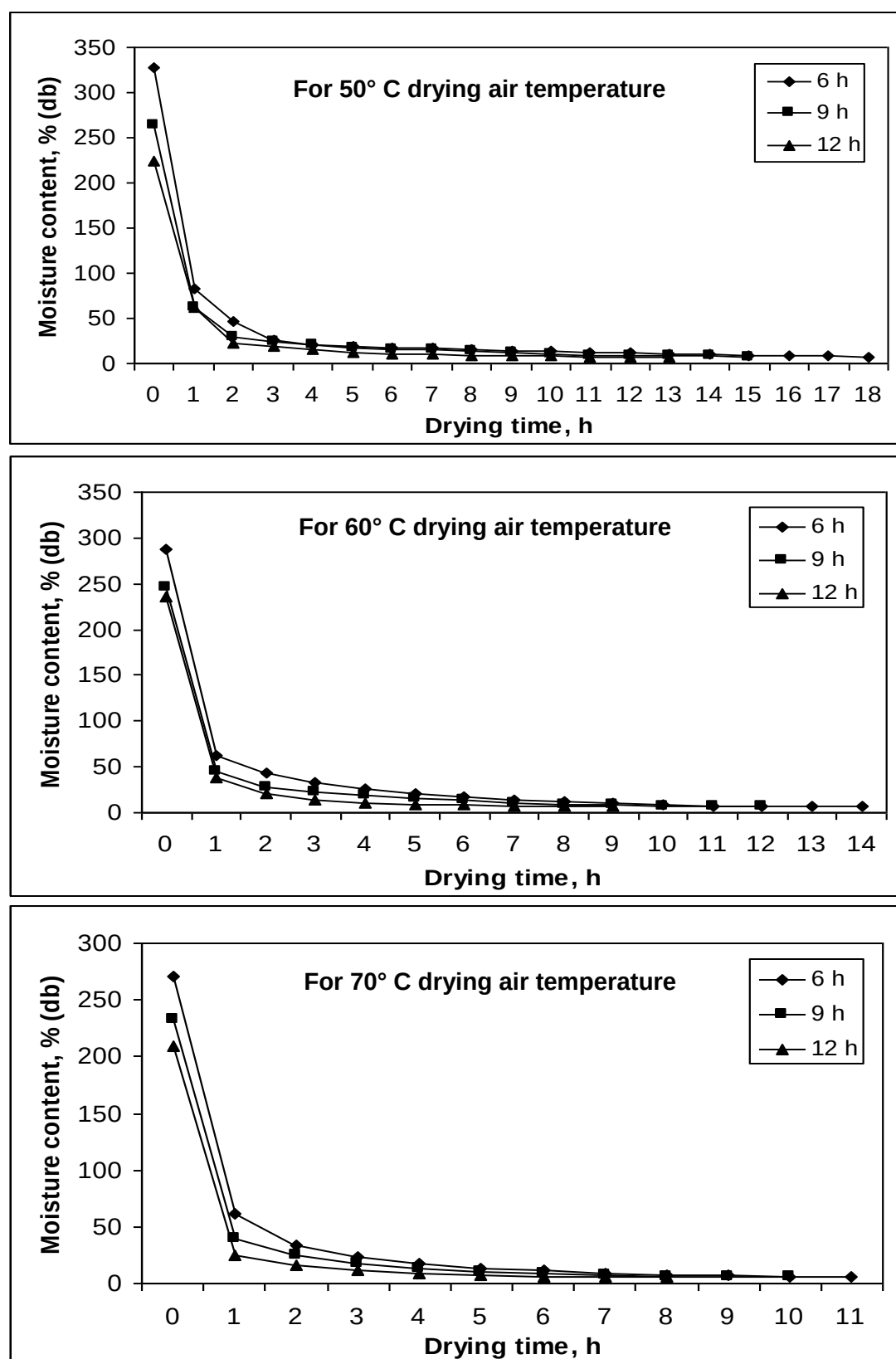


Figure 3: Relationship between moisture content and drying time at different immersion time

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