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Research Article

EFFECT OF PRE-TREATMENTS AND DRYING METHODS ON DRYING CHARACTERISTICS OF GINGER

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Abstract: The present investigation on effect of pre-treatments and drying methods on drying characteristics of Ginger was carried out at P.G. Laboratory, College of Horticulture, Sri Konda Laxman Telangana State Horticultural University (SKLTSHU), Rajendranagar, Hyderabad, during 2016-17. The design adopted in the study was Factorial Completely Randomized Design (FCRD) with pre-treatments, potassium meta bisulphate (KMS) 0.2 % (w/v), ascorbic acid 0.1 % (w/v), citric acid 1.5 g/l and control. Different drying methods namely, microwave oven drying, solar cabinet drying, hot air oven drying and open sun drying and their combination with pre- treatments were used in the study. The drying methods, pre-treatments and their combinations were found to have significant effect on drying characteristics of Ginger slices. Among drying methods, microwave oven and hot air oven drying methods recorded the final moisture content of 9.61 and 9.68 %, respectively. Solar cabinet and open sun drying had the final moisture content of 10.25 and 10.79 %, respectively. Hot air oven drying method exhibited maximum drying ratio of 9.48. The maximum dry recovery percentage was recorded in respect of microwave drying method. Among pre-treatments, KMS (0.2 %) had the maximum moisture loss of the dried Ginger slices with drying ratio of 9.22 and dry recovery percentage of 1.039 %. Among various treatment combinations the minimum moisture content (9.44 %) and maximum recovery percentage (11.01 %) was recorded with pre-treatment KMS (0.2 %) under microwave drying. The maximum drying ratio was noted with pre- treatment KMS under hot air oven drying method. The drying rate was observed at different time intervals and it was found to be faster at 0.5 and 1 hr intervals as the weight loss of Ginger slices during these intervals was high. As time increased the drying rate showed declining trend. At 0.5 hr the drying rate was faster in microwave and hot air oven drying, whereas in solar cabinet and open sun drying, it was found to be slow. Among the pre-treatments, faster drying rate was observed with KMS (0.2 %). From the results it is concluded that during the process of drying, the Ginger slices did not show constant rate of drying and complete drying took place only in the falling rate period. Further, the treatment combination of potassium meta bisulphate (KMS) and microwave oven drying was found to be the best for most of the drying characteristics of Ginger.

Keywords: *Pre-Treatments, Drying and Ginger*

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Introduction

Ginger belongs to the family Zingiberaceae. It is the native of tropical South- East Asia and was introduced into the West Indies, African countries and other tropical countries of the world. India is the largest producer of ginger in the world. India ranks first among dry ginger producers also. Other major producers of ginger in the world are West Indies, Brazil, China, Japan and Indonesia. Major ginger production centres in India are Kerala, Orissa, Andhra Pradesh, Telangana, Himachal Pradesh, Meghalaya and West Bengal. It is sold as fresh ginger and also more frequently, in a peeled and split dried form. Ginger is widely used in pickles, candies and such other preparations and as a medicinal herb. In India, ginger is cultivated in an area of 142 lakh ha with a production of 763 lakh MT. In Telangana state, it is cultivated in an area of 1.8 lakh ha with a production of 12.7 thousand tons [1]. Dry ginger is used for the preparation of ginger powder and other by-products like ginger oil, ginger essence and ginger oleoresin, *etc.* In general, drying of ginger is indigenously performed under Sun [2]. This is a very time consuming method and results in the product of inferior quality. In order to reduce the time of drying and to obtain a good quality final product, mechanical dryers that use heated air are preferred for drying ginger now a days. Besides giving a better quality product, it also avoids the dependency on the vagaries of weather and reduces microbial contamination of the product. Several researchers [3-8] carried out studies on dehydration of ginger either in combination of drying methods with pre-treatments or solely under different drying methods and reported good quality and acceptability of dried ginger. In Telangana state of India, Maran variety of ginger is widely grown for the production of dry ginger. Very little information is available on the drying characteristics of above variety of ginger for the retention of quality parameters. The present study is aimed at investigating the effect of combination of pre-treatments and drying methods on drying characteristics of ginger.

Materials and Methods

The experiment was conducted at the P.G. Laboratory, College of Horticulture, Rajendranagar of SKLTSHU, Hyderabad during the year, 2016-17. The variety of ginger used for the drying studies was Maran. It becomes ready for harvesting (in the month of December) after 8-9 months of sowing when the leaves start yellowing and drying. Big size, healthy, high quality green gingers were taken for the dry ginger production. The ginger rhizomes were procured from the farmers of Medchal village, Rangareddy district, Hyderabad. It was harvested during the month of December at the age of nine months after planting. The harvested ginger rhizomes were used in the present study.

EXPERIMENTAL DETAILS

Experimental Design

The design adopted in the experiment was Factorial Completely Randomized Design (FCRD) with three replications.

Treatment details

Factor I: Drying Methods

1. Microwave oven drying
2. Solar cabinet drying
3. Hot air oven drying
4. Open Sun drying

Factor II: Pre-treatments

1. Potassium Meta bisulphate (KMS) 0.2%(w/v)
2. Ascorbic acid 0.1%(w/v)
3. Citric acid 1.5g/lwater
4. Control (no pretreatment)

Treatments

T_1: Dipping in 0.2%(w/v)KMSsolutionfor5min+Microwavedrying
T_2: Dipping in 0.1 % (w/v) Ascorbic acid solution for 5 min + Microwave drying T3: Dipping in1.5 g/l Citric acid solution for 5 min + Microwave drying
T_4: Control + Microwave drying
T_5: Dipping in 0.2 % (w/v) KMS solution for 5 min + solar cabinet drying
T_6: Dipping in 0.1% (w/v) Ascorbic acid solution for 5 min+ solar cabinet drying T7: Dipping in 1.5 g/l Citric acid solution for 5 min+ solar cabinet drying
T_8: Control + Solar cabinet drying
T_9: Dipping in 0.2 % (w/v) KMS solution for 5 min + Hot air oven drying
T_{10}: Dipping in 0.1% (w/v) Ascorbic acid solution for 5 min+ Hot air oven drying
T_{11}: Dipping in1.5 g/l Citric acid solution for 5 min +Hot air oven drying
T_{12}: Control+ Hot Air oven drying
T_{13}: Dipping in 0.2 % (w/v) KMS solution for 5 min + Open Sundrying
T_{14}: Dipping in 0.1 % (w/v) Ascorbic acid solution for 5 min + Open Sun drying
T_{15}: Dipping in 1.5 g/l Citric acid solution for 5 min + Open Sun drying
T_{16}: Control + Open Sun drying

The raw material was washed thoroughly in running water to remove the adhering soil and extraneous matter. The undesirable portions were removed manually. They were again washed and cleaned properly. The cleaned product was hand peeled by means of a knife. The peeled ginger was sliced into flakes of about 5 mm with the help of a slicer. The thickness of the slices was measured by Vernier callipers. The ginger slices weighing about 100 g in each replication were dipped in CaO 1.5 g/l (used for preventing browning of ginger slices) of water for10 min, after which ginger slices were dipped in different pre-treatment chemicals like Potassium meta bisulphate (KMS) 0.2 % (w/v) for 5 min, Ascorbic acid 0.1 % (w/v) for 5 min and Citric acid 1.5 g/l for 5 min In case of samples chosen for control no pretreatment wasdone. Pretreated ginger slices were dried by different drying methods *viz*., Microwave oven drying, Solar cabinet drying, Hot air oven drying and Open Sun drying. The moisture content percent on dry basis, drying rate (g/hr), drying ratio, and recovery percentage were calculated by using the following formulae [9].

Results and Discussion

The results of the study are presented and discussed below:

Drying characteristics of dried ginger slices

Moisture content (%) (d.b)

The results pertaining to the final moisture content of ginger slices as affected by different drying methods, different pre-treatments and their combination are presented in [Table-1] and depicted in [Fig-1].

Table-1 *Effect of pre-treatments and drying methods on moisture content (%) (db) of ginger slices*

Factors	Pre-treatments				
Drying methods	P1	P2	P3	P4	Mean
D1	9.44	9.5	9.6	9.9	9.61
D2	10.01	10.04	10.24	10.69	10.25
D3	9.52	9.61	9.67	9.94	9.68
D4	10.47	10.7	10.99	11.01	10.79
Mean	9.86	9.96	10.12	10.39	
	S.Em±		CD at 5%		
Drying method (D)	0.03		0.08		
Pre-treatments (P)	0.03		0.08		
D X P	0.06		0.16		

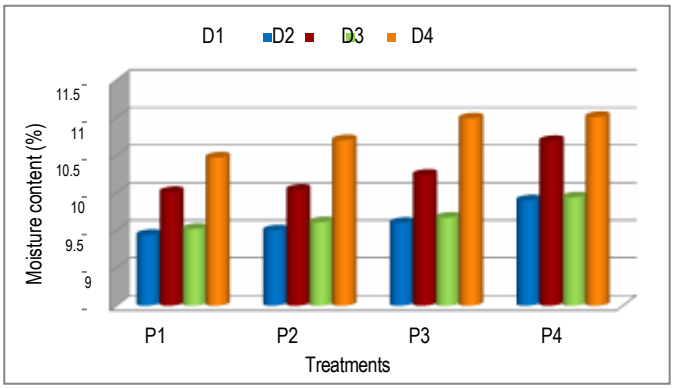

Fig-1 Effect of pretreatments and drying methods on moisture content (%) of ginger slices

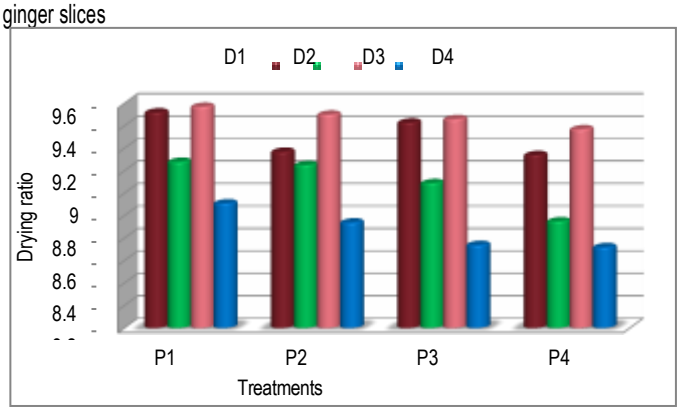

Fig-3 Effect of pretreatments and drying methods on drying ratio of ginger slices

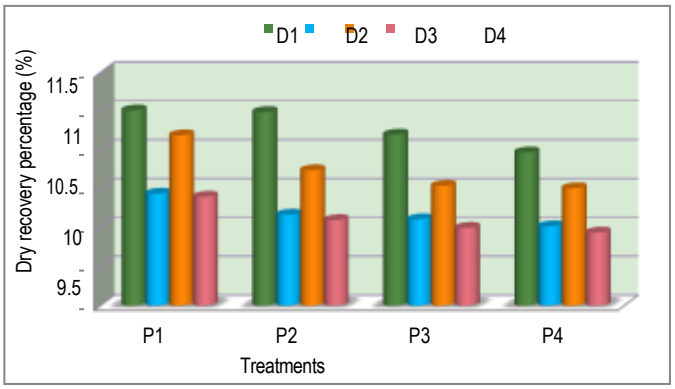

Fig-4 Effect of pretreatments and drying methods on dry recovery percentage of ginger slices

Weight of the sample was taken at an interval of 30 minutes during the experiment and the moisture content on dry basis (d.b) was calculated. The calculated moisture content (d.b) was used as basic data for further analysis. The data reveals that the different drying methods significantly affected the final moisture content of ginger slices. The minimum moisture content of9.61 % and 9.68% was recorded in microwave drying and hot air oven drying, respectively. Whereas, the maximum moisture content of 10.79 % and 10.25 % was recorded in open sun drying and solar cabinet drying methods, respectively. Moisture content of dried ginger slices significantly affected by pre-treatments. The minimum moisture content of 9.86 and 9.96 % was observed with pre-treatments KMS and ascorbic acid, respectively, whereas maximum moisture content (10.39 %) was observed with control. The interaction effects between the different drying methods and pre-treatments were also affecting the moisture content of dried ginger samples significantly in dried ginger slices. The minimum final moisture content (9.44 %) was recorded in KMS treated sample under microwave drying, whereas the maximum final moisture content (11.01 %) was recorded under open sun drying. The time required to bring down the safe moisture (9-11 %) level in drying methods namely micro wave oven drying for 2.5 hr, hot air oven drying for 3 hr,

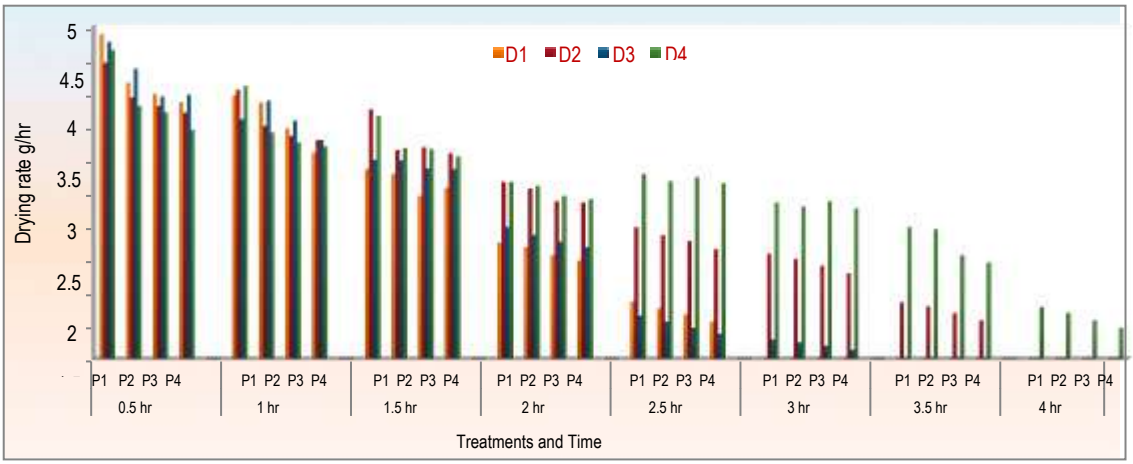

Fig-2 Effect of pre treatments and drying methods on drying rate (g/hr) of ginger slices

solar cabinet drying for 3.5 hr and open sun drying for 4 hr. In this study, the four drying methods used were capable of removing 85-90 % of the moisture in the ginger slices with microwave drying had the highest moisture removal capability [Table-1]. The reduction in moisture content would extend storage period of ginger slices and thereby make them available throughout the year. Similar results were found by different researchers [10-12].

Drying rate (g/hr)

The drying rate of ginger slices was taken at different intervals of time, *i.e.*, 0.5, 1, 1.5, 2, 2.5, 3, 3.5 and 4 hr. The results pertaining to the drying rate of ginger slices as affected by different drying methods, different pre-treatments and their combinations are depicted in [Fig-2]. [Fig-2] shows that the different drying methods significantly affected the drying rate of ginger slices. The maximum drying rate (4.19 g/hr) was observed under microwave and hot air oven drying, whereas the minimum drying rate (3.87 g/hr) was observed under open sun As the drying time increased the drying rate decreased showing an inverse proportion relationship between the drying rate and the drying time. The moisture content of the ginger slices at any time was directly proportional to the drying rate *i.e.*, as the moisture content of the product decreased, the drying rate was also decreased.

Drying ratio

The results pertaining to the drying ratio of ginger slices as affected by different drying methods, different pre-treatments and their combinations are presented in [Table-2] and depicted in [Fig-3].

Table-2 Effect of pre-treatments and drying methods on drying ratio of ginger slices

Factors	Pre-treatments				
Drying methods	P1	P2	P3	P4	Mean
D1	9.52	9.17	9.43	9.14	9.32
D2	9.08	9.05	8.89	8.55	8.89
D3	9.57	9.5	9.46	9.37	9.48
D4	8.71	8.54	8.34	8.32	8.48
Mean	9.22	9.07	9.03	8.84	
	S.Em±		CD at 5%		
Drying method (D)	0.02		0.07		
Pre-treatments (P)	0.02		0.07		
D X P	0.04		0.14		

The data reveals that the different drying methods significantly affected the drying ratio of ginger slices. The minimum drying ratio of 8.48 was obtained under open sun drying. However, the maximum drying ratio of 9.48 in hot air oven drying was obtained, followed by microwave drying (9.32) and solar cabinet drying(8.89).Drying ratio of dried ginger slices was significantly affected by different pre-treatments. The maximum drying ratio of 9.22 was observed with KMS (0.2%), followed by 9.07 and 9.03 with ascorbic acid (0.1 %) and citric acid (1.5 g/l) respectively, whereas the minimum drying ratio was observed (8.84) with drying. The drying rate of ginger slices were significantly affected by different pre-treatments. The maximum drying rate (4.66 g/hr) was observed with KMS (0.2 %), followed by ascorbic acid (0.1 %) and citric acid (1.5 g/l) treatments, with values of 4.04 and 3.84 g/hr, respectively. The minimum drying rate of 3.72 g/hr was observed in control. The interaction effects between the different pre-treatments and drying methods were also found to show significant difference. Maximum drying rate (4.86 g/hr) was observed with KMS (0.2 %) under microwave drying, whereas minimum drying rate (3.42 g/hr) was observed with control under open sun drying. The effect of pre-treatments and drying methods on drying rate at 1 hr, 1.5hr, 2hr, 2.5hr, 3hr, 3.5hr and 4hr may also be seen in [Fig-2]. From the results it is clear that during the process of drying, the ginger slices did not show constant rate of drying and the complete drying took place only in the falling rate period. Further, the changes of drying rate with drying time under different pre-treatments and different drying methods may also be seen in [Fig-2]. It can be noted from [Fig-2] that the faster drying rate was observed during the initial stages of drying. control. The interaction effects between the different drying methods and different pre-treatments were also found to effect drying ratio significantly in dried ginger slices. The maximum drying ratio of 9.57 with KMS (0.2 %) under hot air oven drying, and the minimum drying ratio of 8.32 with control under open sun drying were found.

Dry recovery percentage (%)

The results pertaining to dry recovery percentage of the ginger slices as affected by different drying methods, different pre-treatments and their combinations are presented in [Table-3] and depicted in [Fig-4].

Table-3 Effect of pre-treatments and drying methods on recovery percentage (%) of ginger slices

Factors	Pre-treatments				
Drying methods	P1	P2	P3	P4	Mean
D1	11.01	10.99	10.7	10.47	10.79
D2	9.94	9.67	9.61	9.52	9.68
D3	10.69	10.24	10.04	10.01	10.25
D4	9.9	9.6	9.5	9.44	9.61
Mean	10.39	10.12	9.96	9.86	
	S.Em±		CD at 5%		
Drying method (D)	0.03		0.08		
Pretreatments (P)	0.03		0.08		
D X P	0.06		0.16		

The data reveals that the different drying methods significantly affected the dry recovery percentage of ginger slices. The maximum dry recovery percentage (10.79 %) was recorded under microwave drying, followed by 10.25% and 9.68 % in hot air oven and solar cabinet drying respectively, whereas the minimum dry recovery percentage of 9.61 % was obtained under open sun drying. Dry recovery percentage of dried ginger slices was significantly affected by different pre-treatments. The maximum dry recovery percentage (10.39 %) was recorded with KMS (0.2 %), followed by values of 10.12 % and 9.96 % with ascorbic acid (0.1 %) and citric acid (1.5 g/l), respectively.

The minimum dry recovery percentage (9.86 %) was recorded with control. The interaction effects between the different drying methods and different pre-treatments on dry recovery percentage were also found significant effect in dried ginger slices. The maximum recovery percentage of 11.01 % with KMS (0.2 %) under microwave drying, and the minimum recovery percentage of 9.44% with control under open sun drying were found. This may be due to the fact that final weight of dried ginger slices varies according to drying methods and pre-treatments.

Conclusion

On the basis of results obtained from the present investigation it can be concluded that the drying characteristics of dried ginger slices were significantly influenced by different pre-treatments, drying methods and their combinations. The treatment combination of potassium meta bisulphate (KMS) under microwave oven drying was found to be the best for most of the drying characteristics.

Application of research: Drying of ginger would help in improving shelf life and value addition of produce. This study needs to be conducted with other varieties of ginger, other chemical pre-treatments and other methods of drying for application in real time scenario.

Research Category: Horticulture/Horticulture Engineering

Abbreviations: d.b: Dry Basis, PG: Post-Graduate
SKLTSHU: Sri Konda Laxman Telangana State Horticulture University

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Research project name or number: MSc Thesis

Author Contributions: All authors equally contributed

Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: Medchal village, Rangareddy district, Hyderabad

Cultivar / Variety name: Ginger - *Zingiber officinale*

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

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