Original Research Article

IMPACT OF DIFFERENT DRYING TECHNIQUES ON QUALITY TRAITS OF GINGER (*Zingiber officinale* Rosc.) RHIZOMES

ABSTRACT

Aim: "Impact of different drying techniques on quality traits of Ginger (*Zingiber officinale* Rosc.) Rhizomes"
Study design: The experiment was laid out in a factorial CRD.

Place and Duration of Study: Under the present investigation, ginger was produced at the instruction cum research plots of the Department of Plantation Crops and Processing, Faculty of Horticulture, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal.

Methodology: The study was undertaken with four ginger varieties namely Gorubathan, Suprabha, Suruchi and Suravi to evaluate the effect of different drying methods (sun drying, hot air drying at 50^{O}C, 60^{O}C and 70^{O}C and microwave drying on time required for drying to a moisture content of 8 – 10% and to chemical composition (essential oil, oleoresin content and crude fiber content) of the end product.

Results: Gorubathan variety has the highest essential oil (2.243%) and oleoresin content (14.840%) among the four varieties in this study, highest crude fiber content (5.253%) was observed in Suprabha and highest dry recovery (25.77%) was obtained from Suravi variety. In hot air drying, with increase in temperature essential oil, oleoresin and crude fiber content in dry ginger as well as dry recovery reduced.

Conclusion: With high dry recovery (25.77%), essential oil (2.037%) and oleoresin content (13.510%) and moderately low crude fiber content (4.637%), it can be concluded that Suravi variety is best suitable for producing dry ginger. Apart from microwave drying, sun drying can be recommended as better practice, when hygienically conducted, based on essential oil and oleoresincontent.

1. Introduction

Ginger (*Zingiber officinale* Rosc.) is a perennial herb with thick tuberous rhizome belonging to the family Zingiberaceae. According to Spice Board India Statistics, the area under cultivation in India was 172.04 thousand ha with an annual production of 1843.53 thousand tons in the year 2019-20 (2nd advance estimate). In the world, the production of ginger was 3318.98 thousand tons from a total area of 421.05 thousand ha (FAO, 2020). In West Bengal, the total area and production of ginger was 122.19 thousand ha and 133.24 thousand tons, respectively in the year 2019-20 (Spice Board India, 2020). Ginger is used as ayurvedic remedy for digestive problems and traditional remedy as anti-viral, anti-inflammatory, anti-motion and hypolipidemic, analgesic and immune stimulating properties (Qidwaiet al2003; Malhotra and Singh, 2003). Ginger is used for nausea and vomiting. It is also useful in curing ulcer and preventing heart attack and stroke (Malhotra and Singh, 2003).

The major pungent components in fresh ginger are gingerols and [6]-gingerol is the most abundant among them. Shogoals are responsible for the pungency of dry ginger, these are dehydrated forms of gingerols (Wohlmuth et al 2005). The composition varies with variety, agronomic conditions, drying methods and storage conditions. Dried ginger rhizomes are also used for extraction of essential oil, oleoresin etc., which are used widely in pharmaceuticals, cosmetics, confectionery and beverages etc. Dried ginger is the main product for exporting after fresh ginger. Quality of dried ginger is assessed in terms of volatile oil and fiber content and pungency level (Bag, 2018). The quality of dried product and yield of essential oil depends on many factors including the quality of raw material as well as processing parameters.

The variety of ginger and maturity at the time of harvest are the two main factors related to the raw material used for producing dried ginger. Drying method, temperature and duration of drying are important factors affecting quality of the product (Famurewa et al 2012). The content and composition of volatile oil in dried ginger depends upon their geographical origin, extraction procedures, post harvest treatment, drying conditions and temperature (Bartley and Jacobs, 2000; Kelly et al 1995). It has been reported that degradation of gingerol takes place in acidic environment or at increased temperature (Kubra and Rao, 2012). High drying temperature causes gelatinization of the starch present in ginger and thus reduces the yield of ginger oil (Huang et al 2011). So, the drying process can severely affect physical, chemical and organoleptic quality of an aromatic spice like ginger.

2. Materials and Methods

Under the present investigation, ginger was produced at the instruction cum research plots of the Department of Plantation Crops and Processing, Faculty of Horticulture, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal. The farm is situated at 26^{o} 19ˈ86ˈˈN latitude and 89o 23’53” E longitude, at an elevation of 43 meters above mean sea level. The experimental design followed was Factorial Completely Randomized Design(FCRD) with four ginger varieties Gorubathan, Suprabha, Suruchi and Suravi and five drying methods (Sun drying, Hot air drying at 50 °C, 60°C and 70°C and Microwave drying).

2.1. Biochemical analysis of dried ginger

Dried ginger rhizomes were ground into powder were used for different analysis namely, essential oil content, oleoresin content and crude fiber content.

2.1.1. Analyses of essential oil content in dryginger

Essential oil content in the dried and powdered ginger rhizomes were analyzed by hydro-distillation. Powdered ginger rhizomes (50 g) were hydro-distilled with 500 ml distilled water for 6 hrs in a Clevenger apparatus (AOAC 1975), as done by Jayashree et al. (2014) and Sasidharan et al. (2010). The oil separated was collected in small glass bottles. It was dried over anhydrous sodium sulphate to remove traces of moisture.

Essential oil (%) = Amount of essential oil obtained (g)/ Amount of sample used (g)× 100

2.1.2 Analysis of oleoresin content in dryginger

Oleoresin content in the dry ginger powder was analyzed by solvent extraction (Singh et al, 2005) in Soxhlet apparatus (Pelican Equipments, model: Socsplus-SCS 04R). Hexane was used as the solvent for extraction. 5 g of dried ginger sample was taken in a thimble and it was placed in the cup where 100 ml hexane was heated to 90^0C for 50 min (for extraction) and 180^oC for 30 min (for evaporation the solvent). Then after extraction the sample is taken out and allowed to stand 1 min to cool down. Weight of the cup with oil was recorded with a weighing balance (METTLER TOLEDO, model: PB153-L). Oleoresin content in the sample was calculated from the weight of empty cup and weight of cup with extract.

Oleoresin content (%) = Weight of oleoresin/ Solid present in 5 g weight of sample × 100

2.1.3. Analysis of crude fiber content in dryginger

For analysis of crude fiber content in dried ginger, the samples were defatted, digested with acid and alkali and then dried as done by AOAC (1975). 2.5 g powdered ginger was taken in thimble and extracted for 1 hour with petroleum ether in Soxhlet apparatus (Pelican Equipments, model: Socsplus-SCS 04R). Dilute Sulphuric acid- 1.25% (w/v), Sodium hydroxide Solution- 1.25 % (w/v), Ethanol- 95 % (v/v) used.

Dried sample wasweighed. Crude fiber content of the sample was calculated as below-

Loss in weight on ignition = $(W_2 - W_1) - (W_3 - W_1)$

Crude fiber content (%) = $(W_2 - W_1) - (W_3 - W_1)$/ Weight of sample (g)× 100

Where,

W_1 = Weight of residue before drying, W_2 = Weight of residue after drying and W_3 = Weight of residue after ignite for 30 min at 550^oC

2.2. Statisticalanalysis

The observations recorded in laboratory from different treatments were subjected to statistical analysis as well as DMRT were carried out by using the statistical package adopting SPSS 14. Treatment variations were tested for significance under different parameters performed using critical difference test at 5% level of significance ($p \leq 0.05$) adopted by Fisher and Yates table (Gomez and Gomez, 1984).

3. RESULTS AND DISCUSSION

3.1. Effect of drying methods on essential oil content in different varieties ofginger

Table 1 shows the essential oil content in rhizomes of the four ginger varieties dried by sun drying, hot air drying at different temperatures and microwave drying. The graphical representation of effect of drying methods on essential oil content of different ginger varieties is shown in figure 1. In respect to mean essential oil content in dried ginger, the variety Gorubathan (2.139%) differed significantly at ≤ 0.05 probability level according to Duncan's test for separation of means. Variety Gorubathan (2.139%) had highest essential oil content followed by Suravi (2.037%). Microwave drying (2.080%) was best followed by sun drying (2.055%).

Mean essential oil content among different drying methods was maximum in microwave drying method (2.080%), which was statistically at par with sun drying method (2.055%), and minimum in hot air drying at 70 ºC temperature (1.899%). The ginger varieties also showed significant variation in essential oil content.

Table 1. Essential oil content (%) of different varieties of ginger rhizomes dried by different methods

Variety	Essential oil content (%) in dried ginger					Mean
	Sun drying (D_1)	Hot air drying, 50°C (D_2)	Hot air drying, 60°C (D_3)	Hot air drying, 70°C (D_4)	Microwave drying (D_5)	
Gorubathan (V_1)	2.180	2.160	2.120	1.990	2.243	**2.139^a**
Suprabha (V_2)	1.900	1.867	1.817	1.780	1.920	**1.857^d**
Suruchi (V3)	1.993	1.980	1.977	1.917	2.013	**1.976^c**
Suravi (V_4)	2.147	2.040	1.943	1.910	2.143	**2.037^b**

Mean	**2.055^{a}**	**2.012^{b}**	**1.964^{c}**	**1.899^{d}**	**2.080^{a}**	
	Drying method		**sVariety**		**Drying method × Variety**	
SEm(±)	0.011		0.010		0.021	
C.D. (P≤0.05)	0.031		0.027		0.061	

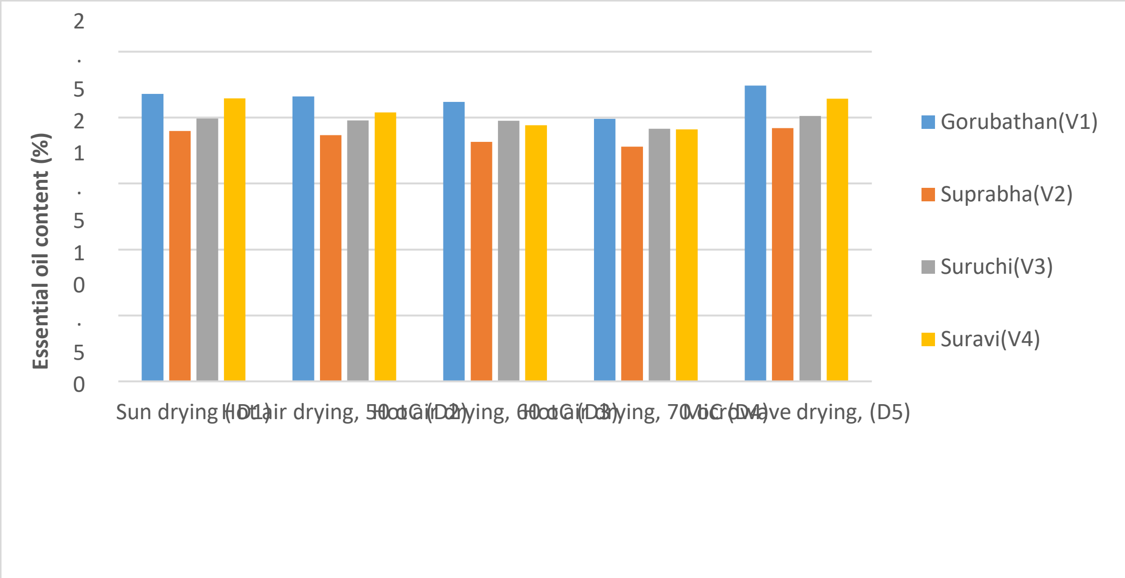

Figure 1. Essential oil content of different varieties of ginger produced by different drying methods

Among the drying methods used for different varieties of ginger, microwave dried samples of Gorubathan variety has the highest essential oil content (2.243%) and hot air dried samples at 70ºC had the lowest essential oil content (1.780%). No data on the composition of ginger of Gorubathan variety was found in literature. Among the other varieties in the present study, Suravi variety was also reported tohave highest essential oil content by ICAR-All India Coordinated Research Project on Spices (Sheo Govind et al. 1998). It can also be observed from table 1 that with increasing temperature in hot air drying, the essential oil content in dried ginger reduces for all the varieties. Essential oils are volatile in nature. Higher temperature during drying may have caused evaporation of these volatile oils from ginger rhizomes. Ginger rhizomes also experience high temperature in microwave drying, as the material is heated uniformly by the oscillation of the water molecules. This process accelerates the rate of drying, thus due to less drying time losses of volatile oil was less than hot air drying method. This may have led to high essential oil content in microwave dried ginger. Mathew et al. (1973) also reported that drying of ginger may lead to loss of volatile oil by evaporation upto an extent of20%. Higher amount of essential oil content in sun dried samples as compared to hot air dried samples was also observed by Jayashree et al.(2013). A loss of about 12% in essential oil content as temperature increased from 50°C to 60°C was also observed by Jayashree et al. (2013). Similar findings were also observed in this study. Huang et al. (2011) also reported higher yield of essential oil (volatile oil) at lower drying temperatures. Higher essential oil content and zingiberene content in microwave dried samples were also observed by Huanget al.(2012).

3.2. Effect of drying methods on oleoresin content of different varieties ofginger

Table 2 shows the oleoresin content in rhizomes of the four ginger varieties dried by sun drying, hot air drying at different temperatures and microwave drying. The graphical representation of effect of drying methods on oleoresin content of different varieties of ginger is shown in Figure 2. It can be observed from table 1 that mean oleoresin content among different drying methods was maximum in microwave drying method (12.487%), followed by sun drying method (12.150%), and minimum in hot air drying at 70ºC temperature (10.432%). The ginger varieties also showed significant variation in oleoresin content. Dried ginger rhizomes of Gorubathan variety had the maximum oleoresincontent(13.523%),followedbySuravi(12.872%),andSuprabhavarietyhas minimum oleoresin (9.045%). Similar to essential oil content in ginger as reported in section 3.1, oleoresin content also reduces with increasing air temperature in hot air drying.

The heat treatment of ginger can lead to degradation of both volatile oil and the pungent principles and thus oleoresin content (Purseglove et al.1981). The findings of the present study also suggest the same. Jayashree et al. (2013) also reported that sun drying yielded in higher oleoresin content than hot air drying method and higher air temperature during drying results in reduction in oleoresin content. Similar to the data on essential oil content of different varieties of ginger, oleoresin content in Suravi variety of ginger was also reported to be highest by ICAR-All India Coordinated Research Project on Spices (Sheo Govind et al. 1998). From the essential oil content and oleoresin content in dry ginger of different varieties, presented in Table 1 and 2 respectively, it can be derived that the essential oil consists of about 15.1 – 21.9% of the oleoresin present. It was also observed that in Suprabha variety of ginger, the amount of essential oil as fraction of oleoresin content was maximum. In Gorubathan and Suravi varieties of ginger the amount of essential oil content in the oleoresin present was low.

Variety	Oleoresin content (%) in dried ginger	Mean

	Sun drying (D_1)	Hot air drying, 50°C (D_2)	Hot air drying, 60°C (D_3)	Hot air drying, 70°C (D_4)	Microwave drying (D_5)	
Gorubathan (V_1)	14.017	13.610	13.010	12.140	14.840	**13.523^{a}**
Suprabha (V_2)	9.613	9.080	8.613	8.103	9.817	**9.045^{d}**
Suruchi (V_3)	11.887	11.390	10.360	9.887	11.780	**11.061^{c}**
Suravi (V_4)	13.083	13.453	12.717	11.597	13.510	**12.872^{b}**
Mean	**12.150^{b}**	**11.883^{c}**	**11.175^{d}**	**10.432^{e}**	**12.487^{a}**	
	Drying method		**Variety**		**Drying method × Variety**	
SEm(±)	0.020		0.022		0.044	
C. D. (P≤0.05)	0.063		0.057		0.126	

Table 2. Effect of drying methods on oleoresin content of different varieties of ginger

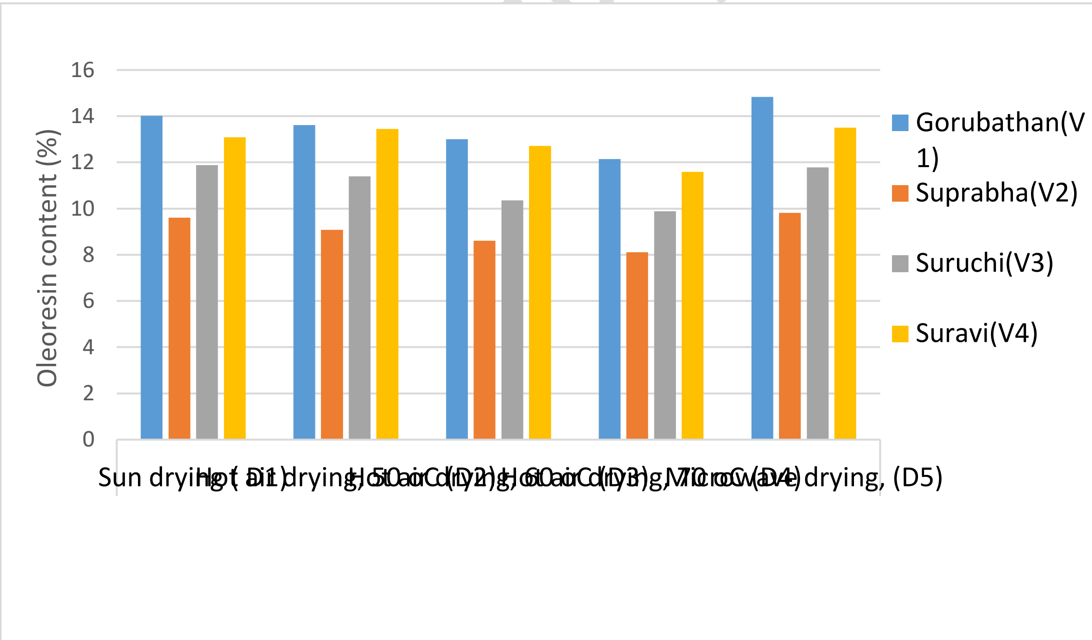

Figure 2. Oleoresin content of different varieties of ginger produced by different drying methods

3.3. Effect of drying methods on crude fiber content of different varieties ofginger

Table 3 shows the crude fiber content in rhizomes of the four ginger varieties dried by sun drying, hot air drying at different temperatures and microwave drying. The graphical representation of effect of drying methods on crude fiber content of different varieties of ginger is shown in Figure 3.

Variety Suruchi had lowest crude fiber content (4.409%) followed by Suravi (4.637%). Hot air drying at 70ºC resulted in lowest crude fiber content (4.738%) in dried ginger followed by hot air drying at 60°C (4.751%). Crude fiber content in dried ginger was significant at ≤ 0.05 probability level according to Duncan's test for separation ofmeans. Mean crude fiber content among different drying methods was maximum in microwave drying method (4.896%), which is statistically at par with sun drying method (4.854%), and minimum in hot air drying at 70°C temperature (4.738%). Significant variation was observed between drying method (4.896%) in microwave drying and hot air drying at 70ºC temperature (4.738%). But the mean crude fiber content in dried ginger did not vary significantly at ≤ 0.05 probability level among microwave drying method (4.896%) and sun drying method (4.854%) or hot air drying method at 50, 60 or 70 ºC, according to Duncan's test for separation of means.

Gopalan et al.(2004) also reported that crude fiber content of ginger powder produced different drying methods like shade, solar, oven and microwave drying methods was almost similar. The range of crude fiber content of dried ginger produced by different drying methods reported by Gopalan et al.(2004) is also similar to the findings of the present study. Generally for production of dry ginger or ginger powder, the ginger varieties with low crude fiber content and good amount of essential oil and oleoresin content are preferred. From the data of crude fiber content of dried ginger of the four varieties used in this study presentedinTable3,itcanbeobservedthatdriedgingerofSuruchivariety(4.409%) has lowest crude fiber content and dried ginger of Suravi variety (4.63%) also has moderately low crude fiber content. Observing the crude fiber content in different varieties of ginger used in this study, ginger rhizomes of Suruchi and Suravi variety can be considered as suitable for production of dryginger.

Variety	**Crude fiber content (%) in dried ginger**	**Mean**

	Sun drying (D_1)	Hot air drying, 50°C (D_2)	Hot air drying, 60°C (D_3)	Hot air drying, 70°C (D_4)	Microwave drying, (D_5)	
Gorubathan (V_1)	5.248	5.108	5.115	5.093	5.253	**5.164**^{a}
Suprabha (V_2)	5.075	5.013	4.983	4.953	5.155	**5.036**^{b}
Suruchi (V_3)	4.440	4.497	4.293	4.313	4.503	**4.409**^{d}
Suravi (V_4)	4.653	4.650	4.615	4.593	4.673	**4.637**^{c}
Mean	**4.854**^{ab}	**4.817**^{bc}	**4.751**^{cd}	**4.738**^{d}	**4.896**^{a}	
	Drying method		**Variety**		**Drying method ×Variety**	
SEm(±)	0.025		0.022		0.050	
C. D. (P≤0.05)	0.071		0.064		N S	

Table 3. Effect of drying methods on crude fiber content of different varieties of ginger

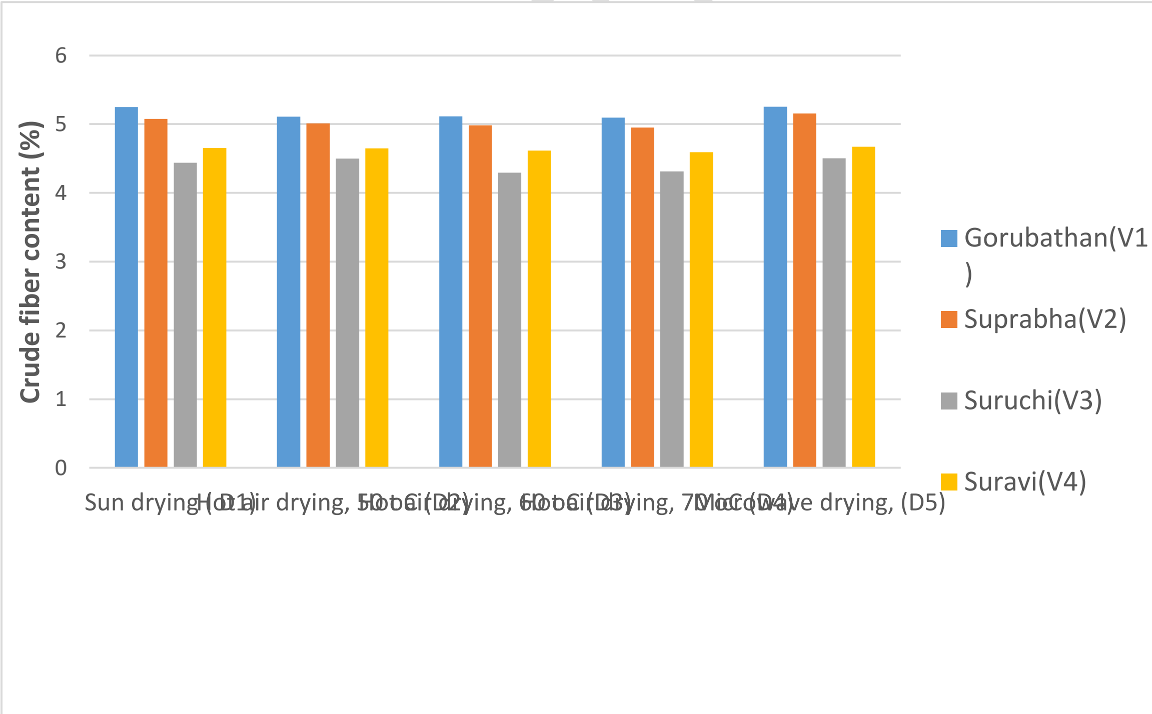

Figure 3. Crude fiber content of different varieties of ginger produced by different drying method

4. Conclusions

Among different drying methods, microwave drying resulted in highest essential oil (2.080%), oleoresin (12.487%) and crude fiber content (4.896%) in dry ginger followed by sun drying method. In hot air drying, essential oil, oleoresin and crude fiber content in dry ginger reduced with increase in temperature. With high dry recovery (25.77%), essential oil (2.037%) and oleoresin content (13.510%) and moderately low crude fiber content (4.673%), it can be concluded that Suravi variety is best suitable for producing dry ginger. Apart from microwave drying, sun drying can be recommended as better practice, when hygienically conducted, based on essential oil and oleoresin content.

6.Competing Interests Disclaimer

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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