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Effects of pre-treatments and drying temperatures on the quality of dehydrated ginger flakes

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Abstract
Maran variety of freshly harvested Ginger rhizomes procured from local market were washed under running water followed by cutting into cubes by using knives and then grated by kitchen grater. Ginger flakes of nearly average uniform size of 45 mm × 15 mm × 3 mm were obtained. A laboratory model tray dryer was used for drying Ginger flakes. Three different samples of Ginger flakes viz. Raw Untreated, Lime Treated (6 h immersion in 2% lime solution), and Osmosed were taken for drying experiment at each level of drying air temperature (50, 60, 70^{o}C). Drying time, Drying rate, Moisture reduction was calculated later with the help of observed data. The dehydrated Ginger flake samples were taken for Quality evaluation by sensory method, colour parameters, rheological characters, and rehydration of final product was also carried out. The dried Ginger flakes showed best rehydration characteristics to yield good quality rehydrated flakes which could be preserved and used during off-season.

Keywords: Ginger rhizomes, drying, drying air temperature, drying rate, quality evaluation

Introduction
Ginger (*Zingiber officinale*) is a spice crop with white or yellow flowers and dark green leaves and a thick root. It is a commonly used spice, which has originated in India. The spice is very common in India and China and is now used all over the world.
Many products can be manufactured from Ginger like dehydrated Ginger, Ginger candy, Ginger powder, Ginger oil and oleoresins and so on. Ginger is an important commercial crop with versatile applications. As condiment, Ginger is used for flavoring many food products like tomato sauce or ketchup, salad dressings, meat sausages, gravies, pickles, curry dishes and so on. It is also used in many medicines as it helps digestion and absorption of food and has antiseptic properties.
Ginger is usually available in three different forms: fresh (green) root Ginger, preserved Ginger in brine or syrup, dried Ginger spice or ground Ginger spice. The processing of Ginger products is an important practice in the food processing industry.
It is expected that world demand for Ginger will be double in the next few years and being the largest producer of Ginger, India can play a major role in achieving this level of demand. In India, more than 75% of Ginger is consumed in the fresh form. Due to developments in drying technology, fresh Ginger that contains moisture content of about 70 to 85% (w.b.) is dried to 10 to 11% level. Dried Ginger is used both as spice and medicine. It contains an essential oil which imparts an aroma, an oleoresin (Gingerin) responsible for the pungent smell of the Ginger. Dried Ginger is also utilized for manufacturing of Ginger powder, Ginger oil, Ginger essence, Ginger oleoresin, soft drink. It is also used as flavoring material in food products.
The conventional practice of Ginger drying is performed under sun which is time consuming method and produces inferior quality product with high loss of volatile oil. Mechanical dryers have also been used to dry Ginger. Osmotic Dehydration emerged as a potential technique for partial removal of water from high moisture foods particularly fruits and vegetables. As the process aims at only partial dehydration it may be used in conjunction with other processing techniques such as air drying, vacuum drying, freeze drying, freezing etc. to obtain a high quality dehydrated product with longer shelf life (Kar and Gupta, 2003) [5]. There are lots of positive benefits of osmotic dehydration including longer shelf life of fruits and vegetables, maintaining nutritional aspects and flavours of fruits and vegetables, preventing occurrence of microbial spoilage and easy transport and handling of fruits and vegetables. Also it has potential advantages of less heat damage, good blanching effect, less enzymatic browning, better retention of flavor, colour, texture and energy saving because no phase change occurs. Moreover, for fruits and vegetables, the osmotic pretreatment prior to other drying methods improves its quality of its nutritional, sensorial and fuctional properties (Alam and Singh, 2008) [1].

Osmotic Dehydration has been reported for the fruits and vegetable products like banana, apple, pineapple, *aonla*, jackfruit, potato, carrot etc. using different approaches. But the osmotic dehydration of Ginger has not yet been studied. So keeping in view the above background information, the present investigation was proposed to be undertaken with objective to study the effects of pre-treatments and drying temperatures on the quality of dehydrated ginger flakes.

Materials and Methods

The fresh and good quality *Maran* variety Ginger rhizomes were procured from local market of Pusa. Rhizomes were properly washed in running water and gently blotted with absorbent paper. The Ginger rhizomes were peeled manually using a knife. For making flakes, the rhizomes were cut into cubes and then grated by kitchen grater.

The average size of Ginger flakes was measured with the help of vernier calliper and screw gauge. The average size of Ginger flakes was found as 45 mm (L) x 15 mm (B) x 3mm (T). The moisture content of prepared Raw Ginger flakes was determined from 77.255 to 84.376 (% w.b.) or 3.396 to 5.400 (kgw/kg.dm).

Drying of Ginger Flakes

The drying operation was carried out with following independent and dependent parameters/variables to study the Drying Characteristics of different types of Ginger flakes.

Experimental Variables

Independent Variables

Type of Sample (Ginger flakes) : Raw Untreated, Lime Treated, Osmosed (Optimized)

Drying air temperature : 50, 60, 70ºC

Dependent Variables

Drying Time (minutes)

Drying Rate (kgw/kg.dm.h)

Moisture Content Reduction (% w.b.)

Experimental Procedure

A laboratory model tray dryer was used for drying Ginger flakes. Three different samples of Ginger flakes viz. Raw Untreated, Lime Treated, and Osmosed were taken for drying experiment at each level of drying air temperature. The drying air temperature was set at the desired level (50, 60, 70ºC) by adjusting thermostat. An electronic balance was used to measure the weight of the samples at different time intervals. Drying was continued till the sample attained constant weight (safe moisture content). Drying time, Drying rate, Moisture content reduction was calculated later with the help of observed data.

Quality Characteristics of Dehydrated Ginger Flakes

The dehydrated Ginger flake samples were evaluated for their quality by sensory evaluation for Colour, Taste, Texture, Appearance and Overall Acceptability. The colour of final product was also determined with the help of Hunter Colour Lab and texture was also determined with the help of Texture Analyzer. Rehydration characteristics of dehydrated Ginger flakes were also determined.

Sensory Evaluation

To the customer point of view, organoleptic characteristics such as: Colour, Taste, Texture, Appearance and Overall Acceptability are important attributes for acceptability of a food product prepared. The dehydrated Ginger flakes were tested for above organoleptic attributes. A performa consisting of basic organoleptic characteristics was prepared and evaluated in a 9-point hedonic scale as per method described by Ranganna (1986) [9]. A group of 15 technically competent panelists of the college/university was asked to judge the quality of the products sensorily and give marks for different quality attributes out of 09 marks.

Results and Discussion

Sensory Evaluation of Final Product

The sensory average scores given by 15 panelists for different quality attributes of the dehydrated Ginger flakes are presented in Table 1.

Table 1: Average scores for different sensory attributes of dehydrated Ginger flake samples

Quality	Type of Sample	Drying Air Temperature		
		50 ºC	60 ºC	70 ºC
Colour	Raw	5.63	5.48	5.18
	Lime treated	7.27	7.19	7.05
	Osmosed	8.37	7.56	7.24
Texture	Raw	5.54	5.15	5.05
	Lime treated	6.76	6.26	5.80
	Osmosed	8.53	7.45	7.19
Taste	Raw	5.25	5.17	5.07
	Lime treated	6.92	6.48	6.16
	Osmosed	8.48	7.48	7.22
Appearance	Raw	5.34	5.26	6.63
	Lime treated	6.78	6.45	6.11
	Osmosed	8.34	7.28	7.06
Overall Acceptability	Raw	5.44	5.23	5.05
	Lime treated	6.80	6.23	6.14
	Osmosed	8.30	7.41	7.18

From Table 1, it is seen clearly that the Osmosed and Lime Treated dehydrated Ginger flakes got high scores as compared to Raw samples in terms of Colour, Texture, Taste, Appearance and Overall Acceptability at all drying air temperatures. The dehydrated Osmosed samples were found best in Colour, Texture, Taste, Appearance and Overall Acceptability followed by Lime Treated and Raw Untreated dehydrated samples. From the average scores in Table 1, it was found that the drying air temperature and sample type both affects the sensory attributes because score shows that with increase in drying air temperature there was decrease in average score. The samples dried at 50 ºC earned the best scores for all sensory attributes as compared to samples dried at 60 ºC and 70 ºC. The maximum scores for dehydrated Osmosed samples dried at 50 ºC were obtained as 8.37, 8.53, 8.48, 8.34 and 8.30 for Colour, Texture, Taste, Appearance and Overall Acceptability respectively. These scores were highest among all three samples within 50 ºC drying air temperature. Thus, the Osmosed Ginger flake samples dehydrated at drying temperature of 50 ºC resulted in the best acceptable quality product which can be used after rehydration in the form of herb, spice and vegetable.

Colour of Final Product

Colour of dehydrated Raw Untreated, Lime Treated and Osmosed Ginger flakes was measured with Hunter Colur Lab and expressed in terms of two colour parameters viz. colour value (L_{Val}) and Total Colour Index (E). These two colour parameters were found to be well correlated with type of sample taken for drying. The range of variation in two colour parameters of Raw Untreated, Lime treated and Osmosed Ginger flakes is presented in Table 2.

Table 2: Colour parameters for Dehydrated Raw Untreated, Lime Treated and Osmosed Ginger flakes samples at different drying temperatures

Drying Air Temperature, ºC	Type of Sample	Hunter Colour values			Total Colour Index (E)
		L	a	b	
50	Raw Untreated	44.57	3.68	10.96	46.045
	Lime Treated	49.93	1.1	4.2	50.118
	Osmosed	48.99	3.99	14.02	51.113
60	Raw Untreated	43.27	2.44	11.17	44.755
	Lime Treated	49.06	1.07	8.36	49.779
	Osmosed	48.91	4.53	13.67	50.986
70	Raw Untreated	43.01	2.32	10.06	44.232
	Lime Treated	48.49	3.6	10.2	49.682
	Osmosed	47.93	4.45	14.82	50.366

Table 2, reveals that the L_{Val} decreases with increasing drying air temperature for all types of samples. However, within the same regime of drying air temperature, the Lime Treated samples had the highest L_{Val} due to use of lime solution. Similarly, the Total Colour Index (E) slightly decreases with increasing drying air temperature for all types of samples. The Total Colour Index (E) for Osmosed samples was higher as compared to Raw Untreated and Lime Treated Ginger flakes within a particular temperature regime due to osmotic agent (sugar) which lightly bettered the colour of Osmosed samples. It was found that Osmotic dehydration played key role in development of best colour (highest E as 51.113) during drying at 50 ºC.

Moisture content in final product

Moisture content in the final dehydrated products was determined by hot air oven method. Observed values are presented in Table 3.

Table 3: Moisture Content in final Dehydrated Ginger flakes at different drying air temperatures

Drying Air Temperature, ºC	Sample Type	Moisture content in final product		
		% w.b.	% d.b.	Kgw/kg.dm
50	Raw Untreated	10.69	11.91	0.119
	Lime Treated	10.72	12.02	0.120
	Osmosed	8.044	8.74	0.093
60	Raw Untreated	9.56	11.80	0.118
	Lime Treated	9.73	12.02	1.120
	Osmosed	7.69	8.33	0.085
70	Raw Untreated	7.52	8.13	0.081
	Lime Treated	8.15	8.87	0.088
	Osmosed	5.67	6.01	0.064

From Table 3, it was observed that the moisture content in final product decreased with increasing drying air temperatures which is a natural phenomenon. The Lime Treated dehydrated Ginger flakes had slightly higher moisture content than Raw and Osmosed Ginger flakes.

Rheological Characteristics of final product

Chips/flakes manufacturers are often interested in studying the effect on firmness/ hardness of the chips. This can be measured by the amount of force required to break the chips. Also, the distance at break is an indication of fracturability, and so may also be of interest. The shorter the distance to fracture, the more easily the product is fractured.

The textural properties of finally dried Ginger flake samples were measured in terms of hardness and fracturability presented under Table 4.

Table 4: Rheological Quality Characteristics of Dried Ginger flake samples

Drying Air Temperature, ºC	Sample Type	Hardness/Peak Force (N)	Fracture Time (sec)
50	Raw Untreated	7.02	0.713
	Lime Treated	6.32	0.685
	Osmosed	8.45	0.816
60	Raw Untreated	6.81	0.635
	Lime Treated	6.28	0.605
	Osmosed	7.68	0.744
70	Raw Untreated	5.98	0.573
	Lime Treated	6.12	0.594
	Osmosed	6.23	0.608

It is evident that from Table 4 the hardness/peak force generally decreases with increase in drying air temperature for all sample types. Since, the fracture time is directly proportional to hardness/peak force; it also showed the same decreasing trend with increasing drying air temperature within a particular drying air temperature regime. It was observed that the Osmosed dried samples had higher hardness and fracture time as compare to Raw Untreated and Lime Treated dried samples. Osmosed dried sample at 50 ºC exhibited the highest value of hardness/peak force of 8.45N with 0.816 sec fracture time. The overall variation in hardness/peak force was observed as 5.98 to 8.45N with fracture time observed as

0.573 to 0.816 sec. The observed values of hardness/peak force and fracture time are in general agreement with the results of Sahu *et al.*, 2008 [10] and Pedreschi *et al.*, 2006 [7].

Rehydration characteristics of final product

The rehydration characteristics i.e. Rehydration Ratio (RR), Coefficient of Rehydration, and Moisture in Rehydrated samples of dried Ginger flakes are shown in Table 5.

Table 5: Rehydration Characteristics of Dried Ginger flakes at different drying air temperatures

Sample Type	Drying air temperature (ºC)	Moisture in rehydrated sample (% w.b.)	Rehydration Ratio	Coefficient of Rehydration
Raw	50	49.035	1.752	0.446
Lime Treated	50	57.053	2.079	0.485
Osmosed	50	66.948	2.782	1.491
Raw	60	47.973	1.738	0.370
Lime Treated	60	50.458	1.822	0.353
Osmosed	60	61.575	2.402	1.243
Raw	70	40.901	1.565	0.336
Lime Treated	70	45.023	1.707	0.327
Osmosed	70	56.675	2.177	1.188

Table 5 reveals that the values of Rehydration Ratio (RR) and Coefficient of Rehydration (COR) were higher in case of dried Osmosed Ginger flakes at all drying air temperatures. The maximum values of RR and COR were found as 2.772 and 1.491 for Ginger flakes dried at 50 ºC drying air temperature. One important thing observed that was sample type and drying air temperature both played important role in rehydration characteristics. The moisture content of rehydrated Ginger flakes samples also followed the same trend. The highest value for Moisture in Rehydrated sample (% w.b.) was found as 66.948% for the Osmosed Ginger flakes dried at 50 ºC drying air temperature. However, the reconstitution properties of all samples were reasonably good. The moisture contents of all the rehydrated samples were between 40.901 to 66.948% (w.b.), which depict that the rehydrated product could very well be utilized for substituting the fresh product in off-season.

Based on all the above quality characteristics, the Osmosed Ginger flake samples dried at 50 ºC emerged as the best sample having desirable quality.

Conclusions

1. In Sensory evaluation the dehydrated Osmosed samples were found best in Colour, Texture, Taste, Appearance and Overall Acceptability followed by Lime Treated and Raw Untreated dehydrated samples. From the average scores, it was found that the drying air temperature and sample type both affects the sensory attributes because scores show that with increase in drying air temperature there was decrease in average scores. The samples dried at 50ºC earned the best scores for all sensory attributes as compared to samples dried at 60ºC and 70ºC. The maximum scores for dehydrated Osmosed samples dried at 50ºC were obtained as 8.37, 8.53, 8.48, 8.34 and 8.30 for Colour, Texture, Taste, Appearance and Overall Acceptability respectively.
2. In case of measured Colour of the final product the L_{Val} decreases with increasing drying air temperature for all types of samples. However, within the same regime of drying air temperature, the Lime Treated samples had the highest L_{Val} due to use of lime solution. Similarly, the Total Colour Index (E) slightly decreases with increasing drying air temperature for all types of samples. The Total Colour Index (E) for Osmosed samples was higher as compared to Raw Untreated and Lime Treated Ginger flakes within a particular temperature regime due to osmotic agent (sugar) which slightly bettered the Colour of Osmosed samples. It was found that Osmotic dehydration played key role in development of best Colour (highest E as 51.113) during drying at 50ºC.
3. The Moisture Content in final product decreased with increasing drying air temperatures which is a natural phenomenon. The Lime Treated dehydrated Ginger flakes had slightly higher moisture content than Raw and Osmosed Ginger flakes.
4. In case of Rheological Characteristics it was seen that potato chips required less amount of force to break the sample hence, its hardness is less and it require less time to fracture as compared with the Ginger flakes. But, there was marginal difference in the two parameters between the Ginger flakes and potato chips, hence, the Ginger flakes can be accepted for its hardness and fracturability.
5. The values of Rehydration Ratio (RR) and Coefficient of Rehydration (COR) were higher in case of dried Osmosed Ginger flakes at all drying air temperatures. The maximum values of RR and COR were found as 2.772 and 1.491 for Ginger flakes dried at 50 ºC drying air temperature. One important thing observed that was sample type and drying air temperature both played important role in rehydration characteristics. The moisture content of rehydrated Ginger flakes samples also followed the same trend. The highest value for Moisture in Rehydrated sample (% w.b.) was found as 66.948% for the Osmosed Ginger flakes dried at 50 ºC drying air temperature. The moisture contents of all the rehydrated samples were between 40.901 to 66.948% (w.b.).

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