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Design and Development of Microwave Assisted Raisin Making Grape Dryer for its Drying Constant

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Abstract

The raisin trade in international market is increasing day by day. USA and Turkey together produce almost 80% of the total raisins of the world. India has achieved the production level in the range of 55,000 to 65,000 t of raisins, which is next to Turkey at world level. Efforts on improvement in quality of the Indian raisins have been initiated to promote the export of this product in world market. As the overall investment in raisin grape production is considerably less as compared to table grape production for export, hence the raisin exporters are expected to accrue better price realization out of this product in terms of superior cost: benefit ratio. India's export of raisins is 314 Mt with the value of 0.473 million US dollars.

Over the past two decades, there has been an increasing interest in microwave drying to reduce drying time and increase the removal of water from agricultural products. Microwave drying has several advantages such as higher drying rate, shorter drying time, decrease energy consumption, and better quality of the dried products. Improving drying processes by reducing energy consumption and providing high quality with minimal increase in economic input has become the goal of modern drying. Any single technique using this technology cannot by itself achieve this target. A combination of existing drying techniques should be considered.

Keywords: drying constant, raisin, microwave, air drying.

Introduction

It was studied that different drying methods that affects moisture ratio. the hot air cabinet alone as a drying method required more time to dry the grapes. The drying rate curves indicated the absence of a constant rate drying period in all drying methods . the microwave oven followed by hot air cabinet dryer as a drying method is most effective and requires minimum time.
The moisture ratio of grapes was affected by drying methods. The hot air cabinet alone as a drying method required more time to dry grapes The microwave oven followed by hot air cabinet dryer as a drying method achieved minimum time for drying.
It is concluded that The drying behavior of the grape shows a change above 70ºC. Which may be due to the rupturing of the skin at these temperatures.

The drying air temperature increases the dehydration rate of the Thompson seedless grapes, owing to the increase in vapors pressure of water and the permeability of the waxy cuticle. It is observed that at a given temperature drying time decrease with increase in velocity of the air.

The constant rate drying period generally observed in the initial drying stages of some agricultural products is absent in the case of pretreated grapes for the temperature range considered. From the initial stage itself the drying rate decreases continuously with the moisture content/time. Temperature range is taken from 50-80^{0}C and velocity range is from 0.25-1.00 m/s.

It is studied that steam blanching that reduced the hot air drying time of grapes by 76.4% also significantly reduced the drying time of microwave-assisted convective drying of grapes. There was 66.7% of reduction in drying time of steam blanched grapes compared to untreated samples to 20% moisture content in wet basis.It is observed that increased levels of sucrose caused the agars to absorb microwave energy more efficiently. At the temperatures above 40°C the loss factor may increase

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with the increase of concentration since more hydrogen bonds will be stabilized by the presence of more hydroxyl groups of sugars.

This phenomenon was also consistent with the previous observations such that when the hot air was insufficient to remove the diffusing grape juice charred spots occurred on grape surface.Research has shown that grape skin is main barrier to mass transfer. this finding led to the application of method of dipping the grapes in a hot emulsion of ethyle oleate so as to reduce skin resistance and further increase in drying rate.

Higher airflow rates are generally adopted in grape drying experiment.The reason for higher airflow rates used in experimental work may be to permit the assumption of uniform drying conditions and therefore to facilitate analysis of drying data. However Chambers and Passingham 1963 used low air flow rates and still obtained comparable drying results. The threshold air velocity, over which no increase in drying rate was observed, was found to be 2-3 m/s . Dielectric properties are very important in MW heating and processing design and applications. Electrical and dielectric properties of many food materials have been reported but information on grape is not available.

Two factors that affect food materials dielectric properties are the charge due to ionic concentrations and water content. Microwave heating is greatly affected by presence of water in foods.From the literature review it is concluded that there is the heating of grapes on microwaves and hot air and results are taken separately for microwave and hot air drying of raisin quality, drying time, sugar content, colour. Analysis was not done in combination with hot air and microwave oven to minimize time, improve quality and colour etc. And the reduction of specific energy is also not calculated in the past.

Materials

As the grape undergoes drying its heating pattern changes with its composition. As 65^0C was set as the microwave cut off temperature, several cycles of microwave heating happened in the pre treatment duration of 5 minutes and number of such cycles depended on the power density applied. Due to these repeated on-off cycles, the heat got dissipating with time. And temperature distribution was pretty uniform all over the berry in 2-3 minutes depending on the power density applied. The fig show temperature gradient during first cycle of heating only.

Heating rates were higher for 2450 MHz than 915 MHz. Uniformity was better in 915 MHz than 2450 MHz. the dielectric properties of the grapes varied linearly with respect to temperature (5-80^0C) and frequency(0.2-10 GHz)

Experimentation

Important components of microwave drying system are-

1. Variable power high frequency generator
2. Waveguide
3. Microwave applicator
4. Variable hot air supply

900 W microwave generator produced microwave at a single frequency, 2450 MHz, A 15 A VARIAC will loaded in the generator circuit to provide a variable power output.

A single mode cavity type applicator will developed for microwave drying studies. The applicator will made up of rolled brass strips. It is rectangular in cross section. The applicator is the actual drying chamber where the sample will subjected to MW heating and drying. the air inlet and outlet ends of applicator are fixed with perforated brass plates. These perforated end plates permitted the easy flow of air but shielded the propagation of microwave. The waveguide side of applicator was covered with a solid plate made of MW transparent plastic material, which transmitted microwave energy into the applicator but shielded the flow of air.

Air blown through the applicator was heated by a bank of electrical heaters and temperature of air was adjustable according to the requirement. A fan was provided in the air duct mix air for uniform temperature before it enters drying chamber. This fan runs on draft of forced air. The perforated wall of the applicator provided further air mixing and even air distribution inside the chamber.

The sample holder will be made with perforated rectangular Teflon plate 2 mm thick.

Provision will be made in applicator to insert fibre optic temperature sensor for measurement of fruit temperature inside a cavity. A luxtron fluroptic

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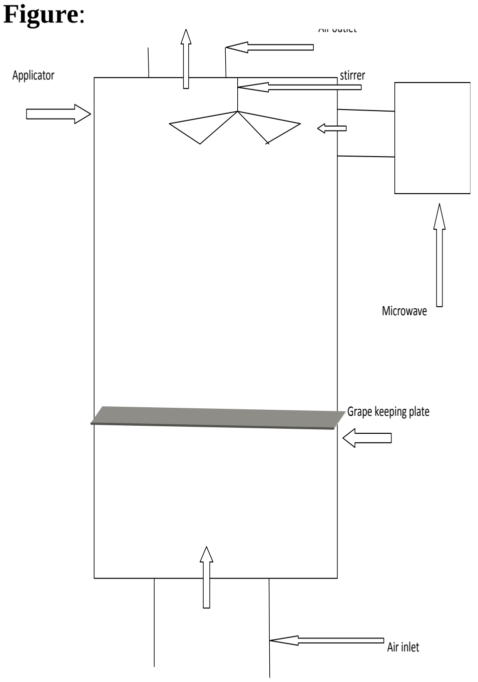
multichannel thermometer will be used to read temperature in MW environment.

The capacity of drying chamber should be of 10 Kg. so the perforated grape dryer mesh plates each of area 60*60 cm^2 should be made. There should be 6 no of such plates. The area of drying chamber is 1 m^2.

The readings are taken such as

1. Initial weight of grapes
2. Microwave time
3. Weight of grapes
4. Air time
5. Weight of grapes

Figure:



Manufacturing and testing

A domestic microwave oven of rated capacity 900 W output power was modified for use as a dryer in the present study. The microwave oven operated at 2450 MHz and the duty cycle was adjustable in increments of 100 W. A blower supplied forced air, the ambient air was conditioned and was supplied at about 24 ^{0}C and 50% relative humidity. When the microwave was off, the set up could be used as a conventional convective dryer. Thompson seedless grapes procured from local market were used for the studies . before the drying trials grapes were removed from cold room and allowed to stand to come to ambient conditions. The stems were removed manually.

The size of grapes was not uniform, only berries having diameter of 0.0175 m which represented the average size, were selected. It was important to choose uniformly sized berries for this study. The sample size for the test 23.75 g. moisture loss due to drying was measured at 1 min interval on microwave and 6-10 min interval on ambient air. For dipping process the solution of ethyl oleate and potassium carbonate is done. For 5 liter of water 90 ml of ethyl oleate is taken and 120 gm potassium carbonate powder is mixed. This mixture is 100% solution. In 90 % concentration solution the grapes are dipped for 30 minutes and readings are taken.

Table 1 readings on set up

Microwave time in min	grapes weight in gm	air time in min	weight in gm
1	28.65	2	28.59
1	28.22	6	27.61
0.5	27.56	10	27.16
0.5	27.1	5	26.96
0.5	26.86	3	26.8
1	26.6	10	26.23
1	26.12	6	25.89
1	25.73	10	25.4
1	25.24	10	24.98
1	24.86	10	24.6
1	24.52	10	24.28
1	24.12	6	23.9
1	23.65	6	23.44
1	23.24	6	23.01
1	22.78	6	22.58
1	22.17	6	21.88
1	21.62	6	21.45
1	21.22	6	20.95
1	20.33	6	20.01
1	19.77	6	19.55

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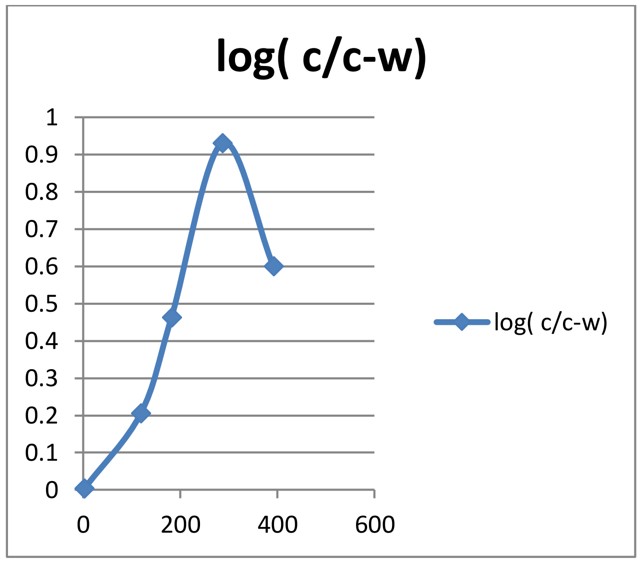
1	19.33	6	19.13
1	18.93	6	18.74
1	18.58	6	18.37
1	18.24	6	18.03
1	15.34	6	15.24
1	15.06	6	14.91
1	14.8	6	14.7
1	14.6	6	14.51
1	14.42	6	14.3
1	14.2	6	14.1
1	14.05	6	13.95
1	13.91	6	13.83
1	13.78	6	13.74
1	13.66	6	13.6
1	13.52	6	13.51
1	13.43	6	13.36
1	13.33	6	13.24
1	13.2	6	13.16
1	13.09	6	13.03
1	13.03	4	12.96
1	12.88	4	12.86
1	12.8	4	12.74
1	12.69	4	12.62
1	12.65	4	12.56
1	12.53	4	12.48
1	12.4	4	12.39

Table 6 calculation of drying constant K

Moisture content %	(1/t) log [c/(c-w)]	k
100%	(1/ 3) log (16.34/ 16.34-0.14)	1.2
80%	(1/119) log(16.34/ 16.34-6.15)	0.0066
60%	1/182 log (16.34/ 16.34-10.70)	0.0025
50%	1/287 log(16.34/ 16.34-14.43)	0.0032 4
40%	1/392 log (16.34/ 16.34-12.39)	0.0015 7



Graph 1 Drying constant vs time

Table 7 calculation for moisture removed

Time min	moisture removed in gm
0	0.14
3	0.98
10	0.45
20.5	0.2
26	0.16
30	0.57
41	0.34
48	0.49
59	0.42
70	0.38
81	0.32
92	0.38
99	0.46

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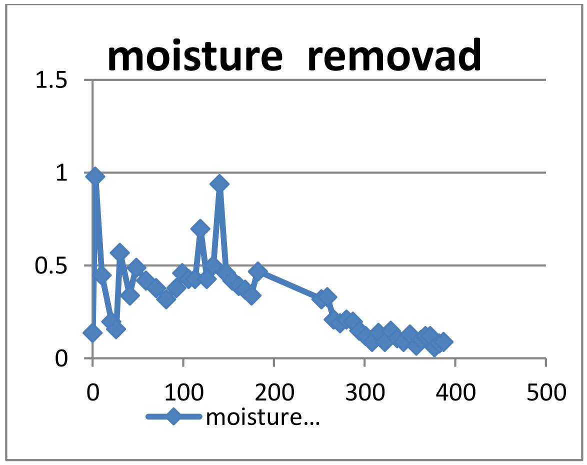
106	0.43
113	0.43
119	0.7
126	0.43
133	0.5
140	0.94
147	0.46
154	0.42
161	0.39
168	0.37
175	0.34
182	0.47
252	0.32
259	0.33
266	0.21
273	0.19
280	0.21
287	0.2
294	0.15
301	0.12
308	0.09
315	0.14
322	0.09
329	0.15
336	0.11
343	0.09
350	0.13
357	0.07
362	0.1
367	0.12
372	0.12
377	0.06
382	0.08
387	0.09



Graph 2 Moisture removal vs time

Conclusion

The drying constant of raisins from Thompson seedless grapes by microwave and air drying combination is found. From the graph it is concluded that upto the 50 % moisture removal the rate of moisture removed from grape increases and then decreases.

So after 50% the use of air drying method should be used for minimum energy consumption. For 57% moisture removal 397 minutes i.e. 6.6 hours is required. After 57% moisture removal it is worthless to use microwave so there is no any moisture removal at this stage bi microwaves. Only air is used to remove moisture.

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