J Food Sci Technol (May–June 2010) 47(3):347–350
DOI: 10.1007/s13197-010-0057-6

ORIGINAL ARTICLE

Effect of mechanical drying air conditions on quality of turmeric powder

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Revised: 22 February 2009 / Accepted: 28 February 2009

Abstract Mother and finger rhizomes 'PCT-8' ('Suvarna') variety of turmeric (*Curcuma longa* L*)* were boiled separately in open pan for 45 min at 100°C. The rhizomes were then dried using tray drier at air temperatures of 45, 50, 55, 60 and 65°C and drying air velocities of 1, 2 and 3 m/sec. The rhizomes were dried to ~10 % (wb) moisture content. The dried rhizomes were polished manually and powdered. The volume of fresh and dried turmeric was determined and shrinkage ratio calculated. The colour of fresh and dried turmeric was determined. Change in colour (ΔE) with drying time was found to be 2.3 and 2.7 for fingers and mothers respectively at 60°C and 2 m/sec air velocity. The oleoresin content was 13.0 and 12.0% for fingers and mothers, respectively. The drying of turmeric took place in the falling rate period and was governed by moisture diffusion. The best quality turmeric was obtained by drying at 60°C air temperature and 2 m/sec air velocity.

Keywords Turmeric · Drying · Rhizomes · Mothers · Fingers · Oleoresin

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Introduction

Turmeric is a perennial herb having 60 to 90 cm height and it belongs to the family *Zingebereceae* and genus *Curcuma*. *Curcuma* has 42 species of which *Curcuma longa* is commercially cultivated (Kannan 1991). Turmeric is grown for its essential oil and yellow colour. Essential oil (turmerol) imparts aroma and flavour, whereas the yellow colour is due to curcumin (deferuloyl methane, $C_{21}H_{20}O_6$). Turmeric has been prized as a dye for centuries. Total production of turmeric in India was 3, 03166 metric tonnes during 2004-2005 (Anon 2005).

Drying is one of the most effective and widely used methods for food preservation. The main aim of drying is to reduce the moisture present in turmeric, which is 70–80% at the time of harvest to a safe limit of 10% for grinding or 6% for safe storage. Vieira and Jorge (1997) studied the drying of turmeric root. The roots were cut into 5 mm slices, treated with saturated steam for 5 min and dried at 45, 55 or 65°C at air flow rate of 1.5 m^3/sec. It was observed that, pretreatment with steam and drying at 65°C was advantageous. Kumar et al. (2000) evaluated the effect of different processing techniques on the recovery of total Curcumin. However, very little work has been done on mechanical drying of turmeric. In order to investigate the potential of preservation of turmeric by mechanical drying, the present study was undertaken to study the effect of different drying air temperatures and air flow velocities on quality of turmeric.

Materials and methods

Fresh turmeric (*Curcuma longa* L*)* cv 'PCT-8' ('Swarna') was procured from the department of Agronomy, PAU in the raw form. The grading of turmeric was done manually to separate finger rhizomes and mother rhizomes. The lateral branches of rhizomes were cut from the central bulb. Both finger and mother rhizomes were boiled separately in

open pan for 45 min at 100°C. Boiling was done to remove raw order, reduce the drying time, gelatinize the starch and produce more uniform product. Boiled turmeric was dried in a drier with electrically heated hot air system. The drying set-up was supplying air up to 70°C. A centrifugal blower delivering airflow up to 6.5 m/sec was powered with 0.75 kW, 1410 rpm, 3 phase electric motor with a direct online starter. The hot air was sucked by the blower through the heaters and was thrown into the drying chamber. A total of 24 heaters (500 W each) constituted the heating chamber. The heaters were vertically fitted in an aluminum chamber having rectangular cross section. The drying chamber for thin layer drying consisted of 24 cuboidal boxes made of carbon steel with dimensions of 19.8 cm × 12 cm ×15 cm. These chambers had a carbon steel screen at the bottom with hole diameter of ~1 mm. The hot air entered the chamber from the bottom, passed through the product and left from the top. The drying chambers were provided with flaps below their bottoms for the entry of air into the chamber. Air velocity was controlled by changing the frequency of supply (to motor). With the change in rpm of motor, the rpm of blower changes which ultimately results in change of velocity of air in the drying chamber. The turmeric was dried at 5 air temperatures of 45, 50, 55, 60 and 65°C and 3 air velocities of 1, 2 and 3 m/sec. The desired air temperature and air velocity were set in the drier and it was allowed to run for 30 min without any load to stabilize the conditions.

The weight loss was taken at regular intervals till the completion of experiment. The polishing of dried rhizome was done manually. The dried rhizomes were rubbed against jute sacks to take out hard layer over them and small roots were removed. Polished turmeric was ground to get the powder. The shrinkage ratio was measured by taking the ratio of final volume 'V' and initial volume 'V_0 'of turmeric as V/V_0. The initial and final volumes of turmeric were determined by displacement method (Mohsenin 1980). The colour of samples was measured by using Hunter Lab Colorimeter (Model mini scan XE plus, Reston, VA, USA) L measures lightness band and varies from 100 for perfect white to 0 for black; 'a' measures redness when positive and green when negative and 'b' measures yellowness when positive and blueness when negative. In terms of three coordinates L, a and b, the data were converted to colour difference (ΔE) and was calculated from the following equation (Gnanasekharan et al. 1992).

$$\Delta E = [(L-L_0)^2 + (a-a_0)^2 + (b-b_0)^2]^{1/2}$$

Soxhlet was used for extraction of oleoresin (Mathew 1971). The data was analysed statistically using response surface methodology at different temperatures and air velocities.

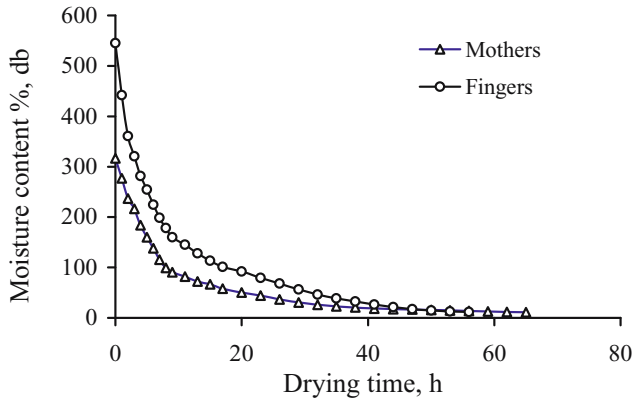

Fig. 1 Drying of turmeric at 60°C and 2 m/sec

Results and discussion

The grading of turmeric resulted in 63.5% of finger rhizomes and 36.5% of mother rhizomes. The decrease in moisture during drying was initially rapid followed by gradual decrease in later part of drying. The drying behaviour of finger and mother rhizomes at air temperature of 60°C and 2 m/sec air velocity is shown in Fig. 1. The time required to dry mother rhizomes was more compared to finger rhizomes (Table 1), which may be due to larger size

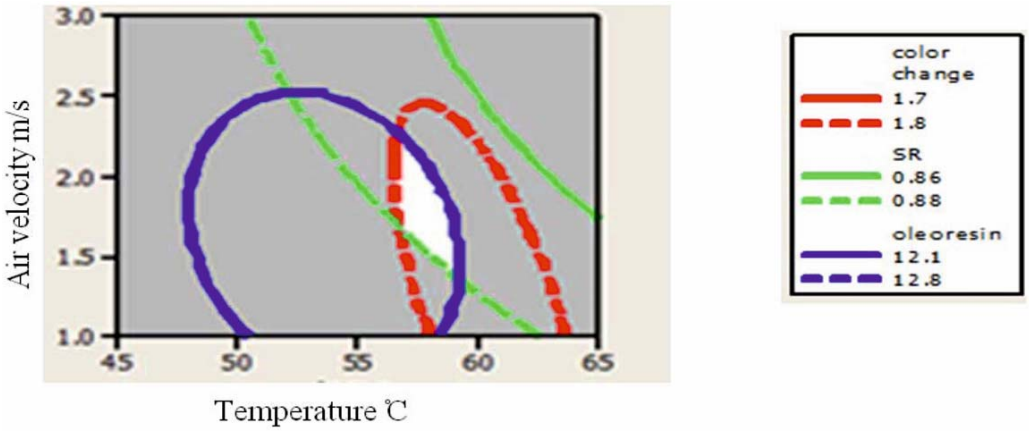

Fig. 2 Overlaid contour plot of colour change, SR, oleoresin (fingers)

Table 1 Effect of drying conditions on quality of dried turmeric

	Drying air temp, °C	Fingers			Mothers		
		1 m/s	2 m/s	3 m/s	1 m/s	2 m/s	3 m/s
Drying time, h	45	92	89	86	110	104	98
	50	80	77	74	92	86	83
	55	71	68	65	77	74	71
	60	59	56	53	68	65	62
	65	50	47	44	62	59	56
Instrumental colour							
L	45	42.0	45.2	43.5	45.7	44.5	41.7
	50	46.3	47.2	45.9	48.4	48.0	42.2
	55	45.2	43.7	45.1	46.7	46.3	43.8
	60	44.9	45.8	46.7	46.5	47.7	48.0
	65	44.3	44.3	46.2	43.3	44.9	44.0
a	45	18.3	18.0	16.6	19.3	19.2	17.6
	50	19.1	19.0	18.5	18.5	19.1	19.3
	55	18.3	18.2	18.5	18.5	18.5	18.5
	60	18.2	18.3	19.1	18.8	18.4	19.0
	65	18.4	18.5	19.2	19.2	18.4	20.8
b	45	23.8	25.6	24.2	26.3	25.7	22.6
	50	26.8	27.0	26.5	28.4	26.7	27.7
	55	25.6	24.5	25.5	26.2	26.3	24.4
	60	26.9	26.2	27.0	26.4	27.4	27.9
	65	26.6	25.1	26.4	24.4	27.8	26.8
ΔE	45	4.3	2.8	3.3	1.1	2.1	4.9
	50	2.8	2.6	2.4	1.4	1.8	3.9
	55	1.7	2.8	1.8	1.7	1.5	2.9
	60	1.7	2.3	2.2	2.5	2.7	2.7
	65	1.8	2.3	2.3	3.1	2.5	2.3
Oleoresin content (%)	45	10.0	11.6	10.6	11.1	11.4	9.6
	50	11.5	12.2	10.2	12.0	12.3	11.3
	55	13.1	13.0	9.8	12.8	12.5	12.7
	60	11.6	13.0	9.2	11.3	12.0	12.3
	65	10.0	8.8	8.5	9.9	11.6	12.0
Shrinkage ratio m/s:Drying air velocity	45	0.910	0.916	0.900	0.950	0.932	0.928
	50	0.913	0.905	0.881	0.932	0.923	0.929
	55	0.916	0.890	0.850	0.922	0.918	0.933
	60	0.896	0.873	0.858	0.891	0.892	0.898
	65	0.870	0.847	0.856	0.855	0.875	0.864

of mother rhizomes. Less time was required for drying at higher air temperature and velocity due to increased drying potential of air. The effect of drying temperature on drying time was higher compared to air velocity. The entire drying of turmeric took place in falling rate period which can be attributed to low diffusion of moisture within the turmeric than that of evaporation of moisture from the surface. It was observed that 1 kg of raw turmeric gave about 170 g of turmeric powder. The 'a' and 'b' values for mother rhizome were more than corresponding values for finger indicating darker colour of the powder from mother rhizomes (Table 1). It was observed that, colour deviation (ΔE) from fresh turmeric was minimum at temperature of 55–60°C and air velocity 2 m/sec.

Oleoresin content first increased with increase in temperature and then decreased with further increase in tem-

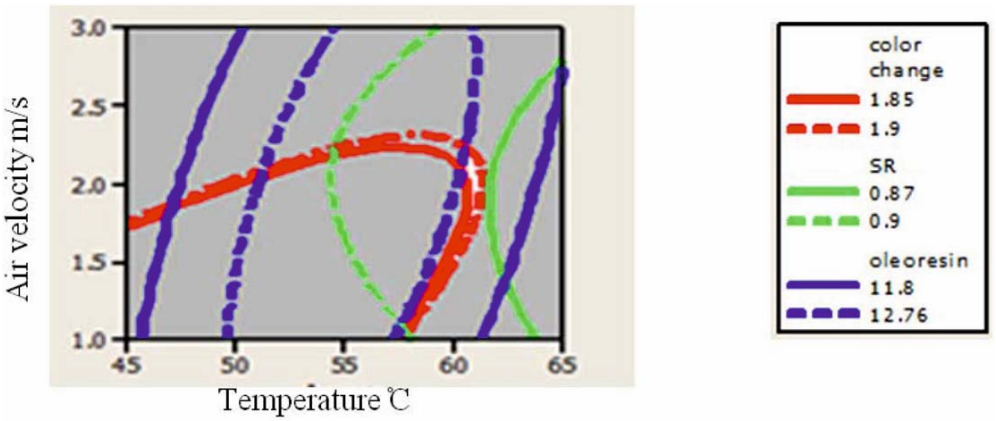

Fig. 3 Overlaid contour plot of colour change, SR, oleoresin (mothers)

Table 2 Analysis of variance (ANOVA) for model fitting

Source	Degrees of freedom	Sum of squares					
		Colour change, ΔE		Oleoresin content, %		Shrinkage ratio	
		Fingers	Mothers	Fingers	Mothers	Fingers	Mothers
Regression	5	5.56	10.98	26.35	17.4	0.0083	0.009
Linear	2	2.51	3.03	6.78	0.34	0.0052	0.008
Quadratic	2	2.49	2.79	18.5	13.9	0.00006	0.0007
Cross	1	0.56	5.15	1.07	3.19	0.00004	0.0024
Product: Residual	6	1.61	0.25	4.44	2.11	0.0014	0.0025
Total	11	7.16	11.24	30.79	19.54	0.007	0.011
Coefficient of determination (R^2)		0.97	0.977	0.956	0.892	0.887	0.878

perature after reaching a peak value for both finger and mother rhizomes (Table 1). However, no systematic trend was found with change in air velocity. The maximum oil yield was at 55°C and at air velocity of 1 m/sec for fingers and at 55°C and 2 m/sec for mothers. Shrinkage ratio decreased with increase in both temperature and air velocity except few experimental errors. This trend was same for both finger and mother rhizomes. The high value of shrinkage ratio indicated lesser shrinkage of turmeric. The response surface methodology gave the optimum value of air temperature of 57–59.5°C and air velocity of 2 m/sec as shown in Figs. 2 and 3 for finger and mother rhizomes, respectively.

To determine the adequacy, the analysis of variance (ANOVA) was carried out (Table 2), which indicated that each measured response had a good fit with coefficient of determination (R^2) of 0.970, 0.906 and 0.887 for colour change, oleoresin content and shrinkage ratio in fingers and 0.977, 0.892 and 0.878 for mothers.

Conclusion

The finger and mother rhizomes of turmeric were dried at 45, 50, 55, 60 and 65°C and air velocities of 1, 2 and 3 m/sec. Both air temperature and velocity affected the quality parameters. The finger rhizomes took less time to dry as compared to mother rhizomes. The optimum drying conditions for best product quality were found to be air temperature of 55–60°C and air velocity of 2 m/sec.

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