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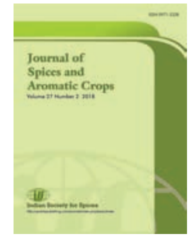

Comparison of quality of dry turmeric (*Curcuma longa*) produced by slicing and other curing methods

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Abstract

The study determines the effect of slicing and curing turmeric (var. Alleppey Supreme) on the quality of dry turmeric rhizomes produced. The turmeric rhizomes were sliced to 5 mm and the curing methods followed were steam curing in TNAU model turmeric boiler for 60 min and traditional water boiling for 60 min. The drying characteristics curves obtained indicated that the time required for drying was significantly reduced by slicing to 127 h (5 days) and the maximum time of 288 h (12 days) was required for complete drying of steam cured turmeric in TNAU boiler. Quality analysis of the dried turmeric samples indicated that the maximum retention of primary metabolites i.e. carbohydrates, proteins, fat and starch was found in turmeric samples cured by water boiling method for 60 min corresponding to 53.15, 3.16, 2.72 and 49.14%, respectively and the maximum retention of secondary metabolites i.e. essential oil, oleoresin and curcumin content were observed in sliced samples and the values corresponded to 6.23, 10.51 and 3.74%, respectively.

Keywords: curing, slicing, steam curing, quality, water boiling

Introduction

Turmeric (*Curcuma longa*), is an important spice in Indian foods with medicinal properties. It is a member of the Zingiberaceae family, and consists of about 110 species, distributed in tropical Asia and the Asia-Pacific region. Fresh rootstock has an aromatic and spicy fragrance, which on drying generates a peculiar medicinal aroma. India is the largest producer, consumer and exporter of turmeric in the world. The production of turmeric in India during 2013-2014 was 5.8 million tonnes from an area of 3.17 million hectares (Spices Board, 2017a). During 2015-16, a total volume of 88,500 tonnes of turmeric valued 921.65 crores was exported as against 86,000 tonnes valued 744.35 crores during 2014-15 (Spices Board, 2017b).

Turmeric is mostly used as a condiment and a small quantity is used in pharmaceuticals and cosmetics. Turmeric possesses a great variety of pharmacological activities and these include its anti-inflammatory, antioxidant, antibacterial, antifungal, antiviral, antimutagenic, anticarcinogenic, anticoagulant, antidiabetic, antifibrotic, antivenom, antiulcer, and hypocholesteremic activities (Braga *et al*. 2003, Chattopadhyay *et al*. 2004).

Curing of turmeric, is an important post harvest processing operation and the process involves cooking of the rhizomes fresh turmeric in boiling water for approximately about 60 minutes and is an essential operation to be done before drying. Curing in boiling water avoids the raw odour, destroys the vitality of fresh rhizomes, yields uniformly coloured product and reduces the drying time. The objective of this experiment was to study the effect of slicing over curing of turmeric on the quality of dry turmeric obtained.

Materials and methods

Turmeric (var. Alleppey Supreme) was obtained from ICAR-Indian Institute of Spices Research (ICAR-IISR), Experimental Farm, Peruvannamuzhi, Kozhikode, Kerala and the experiment was conducted during May 2017 to determine the effect of curing slicing on the quality of dried turmeric rhizomes. Fresh turmeric rhizomes (25 kg) were washed thoroughly to remove the surface impurities and cured by traditional water boiling method for 60 min and another set was steam cooked for 60 min in TNAU turmeric boiler (Viswanathan *et al*. 2002). Another set of washed turmeric rhizomes were sliced manually to a thickness 5 mm and then dried. All the turmeric samples were dried on the roof top concrete floor of ICAR-IISR main building. The weather parameters were recorded during the month of May 2017 and the mean monthly weather conditions for the particular month was calculated. The experiments were carried between 9:00 and 17:00 h. The temperature and relative humidity of ambient air were measured using a digital temperature and relative humidity meter (EQUINOX, EQ-321 S) and the solar radiation was measured using TES1332A model digital lux meter. The weather parameters were recorded at 1 h interval and drying was continued till constant weight was obtained.

The cured turmeric was analyzed for its biochemical qualities in terms of its primary and secondary metabolites. Primary metabolites analyzed were carbohydrate, fat, protein and starch (Sadasivam & Manickam 2008). Secondary metabolites estimated were essential oil, oleoresin and curcumin content. Essential oil was determined by reflux distillation method and oleoresin content was determined by solvent extraction method both as per the procedure described in ASTA (1997) and curcumin was quantitatively extracted by refluxing the material in acetone and estimated spectrophotometrically at 425 nm (ASTA 1968). Moisture content of the fresh samples was determined by toluene distillation method (ASTA 1997). The essential oil samples collected were analyzed using a gas chromatograph (Shimadzu GC 2010) equipped with mass spectroscope (Shimadzu QP-2010) and capillary column (RTX-Wax, 30m × 0.25 mm id × 0.25 ìm). The column temperature was programmed as (Injection port temperature: 250ÚC, flow rate: 1 mL min^{-1}, carrier gas: helium with linear velocity of 48.1 cm/s, Split ratio: 50, Ionization energy: 70 eV, Mass range: 40-650 amu). Statistical analysis of quality parameters were done by AGRES (Version 7.01, Pascal Intl software solutions) statistical software.

Results and discussions

The average temperature on the concrete floor of the roof top varied from a minimum of 38.25°C at 9.00 h to a maximum of 52.31°C at 12.00 h. The average relative humidity varied from 48.95% at 9.00 h to 61.32% at 17.00 h.

Drying characteristics

The drying characteristics curves (Fig. 1) of sliced rhizomes, turmeric rhizomes cured by steam in TNAU turmeric boiler for 60 min and by traditional water boiling method for 60 min, followed by sun drying of all the samples, indicated that during drying the moisture content decreased continuously. The drying time reduced significantly to 127 h (5 days), when the rhizomes were sliced to 5 mm thick and dried. The moisture content of turmeric rhizomes cured by water boiling method decreased from an initial moisture content of 418.96% dry basis (d.b) to final moisture of 11.41% (d.b) and it took 240 h (10 days) for complete drying. While turmeric rhizomes steam cured in TNAU turmeric boiler for 60 min took maximum time of 288 h (12 days) for complete drying. The drying rate was faster for sliced turmeric samples and corresponded to 0.57 kg per kg of dry matter per hour.

Borah *et al.* (2015) carried out drying of turmeric in a solar conduction dryer. The temperature of drying air achieved was around 39–51°C for an ambient temperature in the range of 25–28°C. The experiment revealed that in 12 h of effective drying time, the moisture content reduced from 78.65% wet basis (w.b) to 6.36% (w.b) for whole turmeric samples and to 5.50% (w.b) for sliced turmeric samples. The study also indicated that drying curve of sliced samples showed more uniform falling rate in comparison to that of whole samples.

Physical properties of dried rhizomes

The dry recovery of turmeric rhizomes varied from a minimum of 20.80% for sliced turmeric to a maximum of 22.20% for traditional water boiled turmeric with corresponding moisture content of 9.24 and 9.86%, respectively (Table 1). The analysis of variance indicated ($p<0.05$) that the there was no significant variation in the dry recovery of turmeric sample obtained by different treatment methods.

Lokhande *et al.* (2013) studied the effect of curing and drying methods on dry recovery of three turmeric cultivars Salem, Krishna and Tekurpetha and revealed that there was no significant difference between cured and uncured turmeric samples for all the three cultivars. However, the samples dried under shade-net were having higher dry recovery than other drying methods like sun drying and mechanical drying for all the three cultivars studied.

Variation in primary metabolites

The variation in primary metabolites of sliced samples in comparison to cured samples indicated that maximum availability of carbohydrates, proteins, fat and starch was found in turmeric samples cured by water boiling method corresponding to 53.15, 3.16, 2.72 and 49.14%, respectively (Table 2). This was followed by steam cured turmeric samples in TNAU boiler with values corresponding to 48.82, 3.15, 2.63 and 42.69%, respectively showing significant reduction in carbohydrate, starch and fat content. Lowest values of primary metabolites were observed in sliced samples and the analysis of variance showed that there was significant reduction ($p<0.05$) in the carbohydrate, fat and starch content of sliced turmeric samples and the values corresponded to 42.14, 2.12 and 40.80%, respectively. However, the variation in protein content was nonsignificant.

Dried turmeric rhizomes showed average composition of 69.4% of carbohydrates, 13.1% of water; 6.3% of proteins, 5.1% of fats, 3.5% of ash,

Table 1. Variation in physical properties and primary metabolites of sliced and cured turmeric

Treatment	Physical properties			Primary metabolites			
	Drying time (h)	Dry recovery (%)	Moisture content (%)	Carbohydrate (%)	Protein (%)	Fat (%)	Starch (%)
T1 - Sliced turmeric rhizomes 5 mm thick	127 (5 days)	20.80^{c}	9.24^{c}	42.14^{c}	3.13^{c}	2.12^{b}	40.80^{c}
T2 - Turmeric rhizomes steam cured in TNAU boiler for 60 min	288 (12 days)	21.4^{b}	9.73^{b}	48.82^{b}	3.15^{b}	2.63^{a}	42.69
T3 - Turmeric rhizomes cured by traditional water boiling for 60 min	240 (10 days)	22.2^{a}	9.86^{a}	53.15^{a}	3.16^{a}	2.72^{a}	49.14^{a}
SED		0.81	0.03	0.06	0.70	0.07	0.27
CD(0.05)		NS	0.07*	0.14*	1.72^{NS}	0.17*	0.66*

Table 2. Variation in secondary metabolites of sliced and cured turmeric

Treatment	Secondary metabolites			Essential oil constituents				
	Essential oil (%)	Oleoresin (%)	Curcumin (%)	β-sesquiphellandrene (%)	ar-curcumene (%)	turmerone (%)	ar-turmerone (%)	α-phellandrene (%)
T1 - Sliced turmeric rhizomes 5 mm thick	6.23[a]	10.51[a]	3.74[a]	2.58[c]	1.37[a]	0.98[c]	43.75[a]	2.48[c]
T2 - Turmeric rhizome steam cured in TNAU boiler for 60 min	5.73[b]	10.26[c]	3.52[c]	3.14[b]	1.13[c]	1.06[b]	41.71[c]	3.60[b]
T3 - Turmeric rhizomes cured by traditional water boiling for 60 min	5.87[b]	10.35[b]	3.65[b]	3.33[a]	1.15[b]	1.80[a]	42.82[b]	3.75[a]
SED	0.09	0.67	0.008	0.81	0.82	0.50	0.81	0.81
CD(0.05)	0.22*	1.63[NS]	0.01*	NS	NS	NS	1.99*	NS

2.6% of fibers and the curcuminoids content varied between 2 and 9%, depending on geographic conditions (Esatbeyoglu *et al*. 2012).

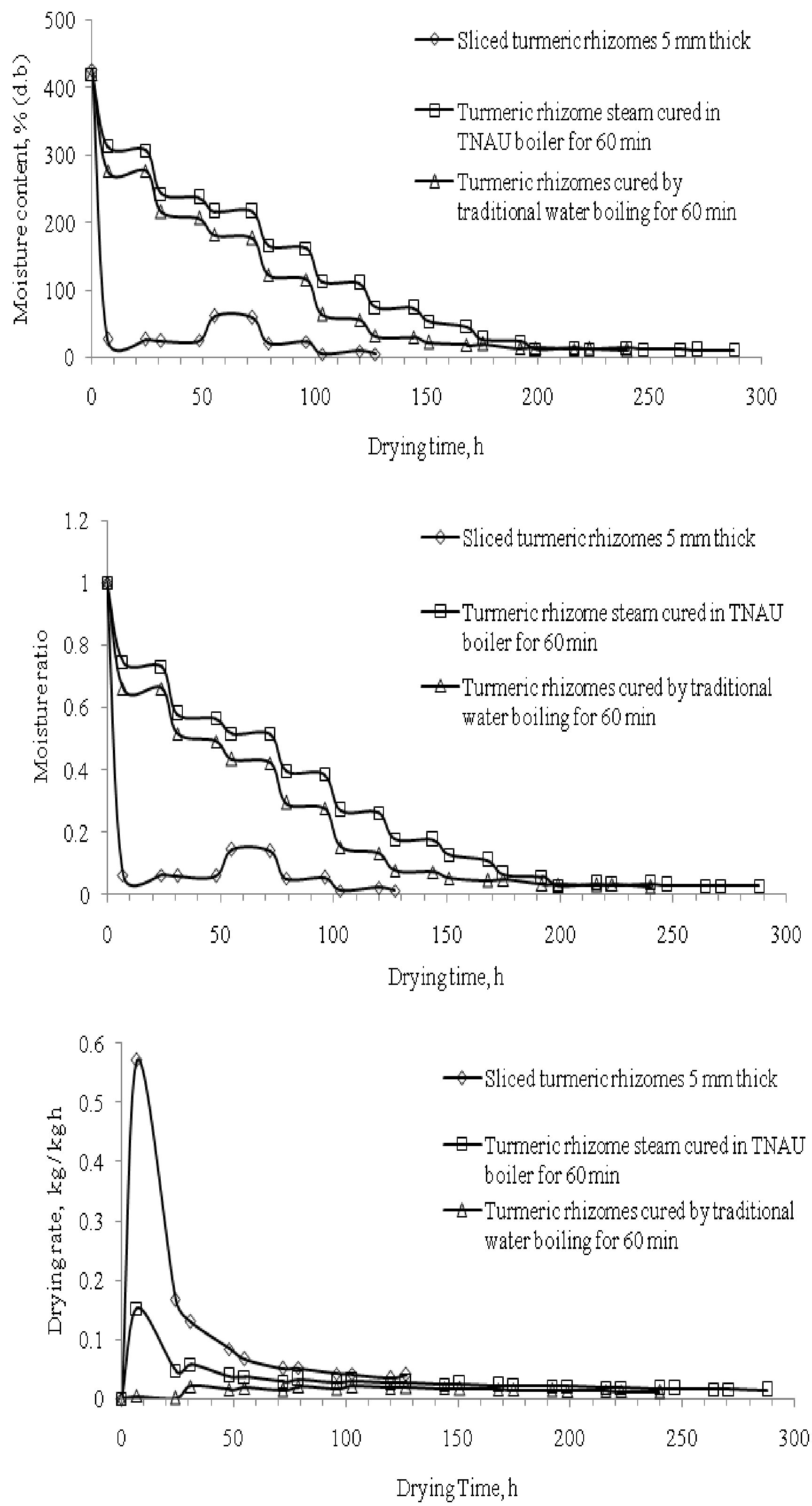
Variation in secondary metabolites

Variation in secondary metabolites of sliced samples in comparison to cured turmeric samples indicated that maximum retention of secondary metabolites was observed in sliced samples. The essential oil, oleoresin and curcumin content of the sliced turmeric were 6.23, 10.51 and 3.74%, respectively (Table 3). Analysis of variance indicated that there was significant reduction in the secondary metabolites of turmeric samples cured by water boiling method with values of essential oil, oleoresin and curcumin content varying as 5.87, 10.35 and 3.65%, respectively and the lowest values were obtained for turmeric samples steam cured in TNAU boiler with values corresponding to 5.73, 10.26 and 3.53%, respectively.

Gounder & Lingamallu (2012) reported that the yield of volatile oil obtained (on a dry weight basis) for fresh, dried and cured turmeric rhizomes were 3.52 ±0.23, 3.05 ± 0.15 and 4.45 ± 0.37%, respectively. However, the yield of volatile oil obtained from cured rhizome was 26% higher than that of fresh and 46% higher than that of dried samples. This may be due to the variation in curing and drying methods. In case of cured sample, the rhizomes were cooked in boiling water and dried in shade. There is no much damage to oil cells and the oil loss during drying process is reduced. Govindarajan & Stahl (1980), reported that during the process of curing turmeric, the starch granules get gelatinized due to thermal processing and this facilitates uniform drying. Further, the rhizomes show volume expansion during cooking due to gelatinization of starch present in them and the volume of cooked rhizome is more than that of uncooked turmeric samples. The cured samples are easy to grind and the extractability of oil is more, when compared to the uncured sample. Asekun *et al.* (2007) reported that the method of drying had a significant effect on the quality and quantity of the volatile oils obtained.

Suresh *et al*. (2007) examined the loss of active ingredient curcumin during heat processing of turmeric by subjecting fresh turmeric to various cooking levels and found that curcumin loss from heat processing of turmeric was 27-53% with maximum loss during pressure cooking for 10 min.

Prathapan *et al.* (2009) examined the effect of heat treatment on curcuminoid content of fresh turmeric rhizome. The rhizomes of fresh turmeric were subjected to heat treatment at different temperatures varying from 60 to 100°C for durations varying from 10 to 60 min and the quantification of curcuminoids was made using high performance thin layer chromatography (HPTLC). The studies indicated that there was no significant difference in the concentration of



A

B

C

Fig. 1. Drying characteristics curves of sliced, steam cured and water cured turmeric. (A) Moisture content versus drying time, (B) Moisture ratio versus drying time and (C) Drying rate versus drying time

curcuminoids among the heat-treated samples. But, however, in the sun-dried samples, there was a significant reduction in curcuminoid concentration.

Lokhande *et al*. (2013) reported that the retention of curcumin was low in uncured samples than cured samples. Higher retention was observed in samples cured with improved method where the cleaned fingers were taken in perforated galvanized mild steel drums and immersed in a kettle containing alkaline solution (0.1% Sodium bicarbonate) and boiled till the fingers became soft.

Jayashree & Zachariah (2016) studied the effect of curing Prathiba variety of turmeric for various curing time of 30, 45 and 60 min by steam cooking in TNAU boiler and observed that with the increase in curing time there was significant reduction in curcumin content and maximum retention of the curcumin was obtained for turmeric cured for 30 min.

Variation in volatile oil constituents of essential oil

Variation in constituents of volatile oil of turmeric as analysed by GC-MS indicated that maximum retention of ar-turmerone was obtained in sliced turmeric samples and the values corresponded to 43.75% and analysis of variance indicated that there was significant reduction of this constituent in turmeric samples cured by traditional water boiling and in turmeric samples steam cured in TNAU boiler (Table 4). However, the other constituents like the ar-curcumene, turmerone, β-sesquiphellandrene and α-phellandrene showed no significant variations by following different curing methods.

Raina *et al*. (2002) reported that about 84 compounds were present in the oil of turmeric rhizomes obtained from North Indian Plains, of which the major compounds identified were eucalyptol (11.2%), α- turmerone (11.1%), β-caryophyllene (9.8%), ar-turmerone (7.3%) and β-sesquiphellandrene (7.1%). Cousins *et al*., (2007) concluded that the chemical composition of the rhizome oil depends on the genotype, field conditions, and post harvest processing of turmeric. Gounder & Lingamallu (2012) reported that the major constituents of volatile oil of turmeric were α-turmerone (26.5–33.5%), ar-turmerone (21.0–30.3%), and β-turmerone (18.9–21.1%).

Pradeep *et al*. (2016) investigated the influence of blanching and drying methods on the quality of turmeric rhizomes and indicated that the quality of unblanched sliced rhizomes dried using hot air drier (50±2^{0}C and 58-63% RH) was superior based on physico-chemical and colour values. The important constituents of the turmeric oil from blanched and unblanched rhizomes were tumerone, 61.54 and 62.91%; curlone, 27.77 and 25.35%; and cyclohexane, 1.73 and 1.32%, respectively.

The study concluded that slicing significantly reduced the drying time to 127 h. Turmeric rhizomes cured by traditional water boiling for 60 min took 240 h for complete drying. While turmeric rhizomes steam cured in TNAU turmeric boiler for 60 min took 288 h for complete drying. Maximum retention of primary metabolites was obtained in turmeric rhizomes cooked by water boiling method and maximum retention of secondary metabolites was obtained from sliced samples. Quality profiling of volatile oil of turmeric by GC-MS indicated that maximum retention of ar-turmerone in sliced turmeric samples and no significant variations was found in other constituents of turmeric during different processing methods.

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