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Quality variation of turmeric during polishing in a power operated turmeric polisher

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Abstract

Polishing of turmeric is an important post harvest operation done after drying to improve the surface colour and to obtain a smooth surface finish. Turmeric (variety IISR Prathiba) was cleaned and cured for 1 h in a steam operated turmeric boiler and one batch was dried in a solar tunnel drier of size 9 m × 4 m × 2.6 m and the other batch was sun dried on cemented concrete floor until constant weight was obtained. The turmeric obtained by both the methods were subjected to polishing in a power operated turmeric polisher to obtain clean and yellow coloured turmeric. Based on the physical appearance and surface finish, it was revealed that turmeric polished for 30 min was optimum to obtain turmeric rhizomes of marketable acceptance and the degree of polishing for solar tunnel dried turmeric was 5.45% and for sun dried turmeric it was 5.20%.

Keywords: *Curcuma longa*, polishing, quality, solar drying, sun drying

Introduction

Turmeric (*Curcuma longa* L.) is an important spice and cash crop of India and is the largest producer and consumer of turmeric in the world. The production of turmeric in India during 2019-2020 was 11,78,750 tonnes from an area of 2,96,181 hectares (Spices Board 2022). The important states producing turmeric are Telangana, Tamil Nadu, Andhra Pradesh, Odisha, Karnataka, West Bengal, Gujarat, Meghalaya, Maharashtra, Assam etc. Turmeric is used in many culinary preparations to add flavour and colour to foodstuffs and is the principle ingredient of curry powder. The curcumin extracted from turmeric is used as colourant and as a dye in textile industry. Turmeric is found to possess many beneficial biological activities such as anti-inflammatory, anti-oxidant, anti carcinogenic, anti-mutagenic, anti-coagulant and anti-infective effects (Sarker & Nahar 2007). The important post harvest operations in turmeric processing are curing, drying and polishing. Turmeric after drying has a rough appearance with very dull surface colour. To obtain a better surface finish, turmeric is polished during which the surface scales, small rootlets and soil particles adhering on the surface are removed (Powar *et al*. 2015). Polishing is done either manually or by mechanical means (Pal *et al*. 2008). In the manual polishing process, the dried turmeric is rubbed on the hard surface or trampled under feet by wrapping the turmeric rhizomes with gunny bags. The mechanical polishing is performed in polishing drums rotated by hand or by power. Sukumaran and Satyanarayana

(1999) reported a mechanical polisher of capacity 600-700 kg h^{-1} for turmeric operated by 2 hp electric motor. The unit consisted of a mild steel drum of 880 mm diameter with meshes wrapped one above the other, and rests on a ball bearing at two ends on a rectangular stand. The rotating speed of the drum was maintained at 30-32 rpm. Pal *et al.* (2008) developed a pedal operated turmeric polisher of capacity 50 kg which took 30 min to polish a batch of turmeric to achieve 6% polishing when the drum was rotated below the critical speed of 45 rpm. In the turmeric growing regions of Telangana, Tamil Nadu, Andhra Pradesh and Maharashtra there are several models of such turmeric polishers developed mostly by farmers and fabricated by local manufacturers. In such cases, the data on evaluation of polishers are not available. Hence, the present study was taken up with the objective to evaluate the power operated mechanical polisher available at ICAR-Indian Institute of Spices Research (ICAR-IISR), Kozhikode and to determine the quality of polished turmeric.

Materials and Methods

Fresh turmeric (variety IISR Prathiba) having an initial moisture content of 84.50% was procured from a farmer at Wayanad and the fingers were separated from mother rhizomes, washed and cleaned. Curing of rhizomes was done in the TNAU model steam operated turmeric boiler (Viswanathan *et al.* 2002). Cured turmeric rhizomes were sun dried on a clean concrete surface at ICAR-IISR, Experimental Farm, Peruvannamuzhi, Kozhikode. The average temperature on the concrete floor was about 39.63°C, while the ambient temperature varied from 28-36°C and relative humidity varied from 34.16 to 61.52%. Another batch of cured turmeric rhizomes were dried in the solar tunnel drier (9 m × 4 m × 2.6 m) covered by UV stabilized semi-transparent poly film sheet of 200 microns thickness and the loss in mass during drying was recorded for every 3 hours. Maximum average temperature, relative humidity and sun shine intensity recorded inside the solar tunnel drier were 46.99°C, 62.07% and 457.50 Wm^{-2}, respectively. The drying was continued till constant mass was obtained. Drying of turmeric in a solar tunnel dryer took 9 days (213 h) for complete drying from an initial moisture content of 545.16% (d.b) and final moisture content of 13.68% (d.b.), while conventional sun drying method took about 10 days (235 h) to reduce from an initial moisture content of 545.16% (d.b) to a final moisture content of 12.88% (d.b).

Polishing of turmeric

Experiments on polishing of turmeric were done in a power operated turmeric polisher (Fig. 1) available at ICAR - IISR, Kozhikode which consists of an octagonal wooden drum made of eight numbers of rectangular wooden pieces each having a dimension of 91.5 cm × 31 cm × 3 cm. The inner surface of each wooden piece is provided with 72 numbers of mild steel nails of size 5.08 cm × 0.03 cm. Two rectangular mild steel meshes of size 15 cm × 7.5 cm are also provided in each wooden piece. The mesh is made of 2.5 mm mild steel wires having square opening of size is 3 mm. One hp motor is connected to the shaft of the octagonal drum with a belt drive system which rotates the octagonal drum at a low drum speed (Hoque and Hossain 2018) of 32 rpm. The unit is mounted on mild steel frame of size 195 cm ×100 cm ×125 cm. Approximately about 50 kg of dried turmeric having a moisture content of about 11.71% was loaded in to the power operated turmeric polisher and initially polished for 15 min. The polishing of turmeric inside the drum was achieved by surface abrasion of turmeric against the walls of the polisher and between the turmeric rhizomes. The dust and external skin of the turmeric is released through the mesh opening of the polishing drum. The degree of polish was checked at definite time interval by stopping the polisher and unloading the material from the polisher and the mass of the polished turmeric was recorded. Further, a sample of 150 g was taken for quality analysis which was recorded separately.

The partially polished turmeric was reloaded into the polisher and the experiment was

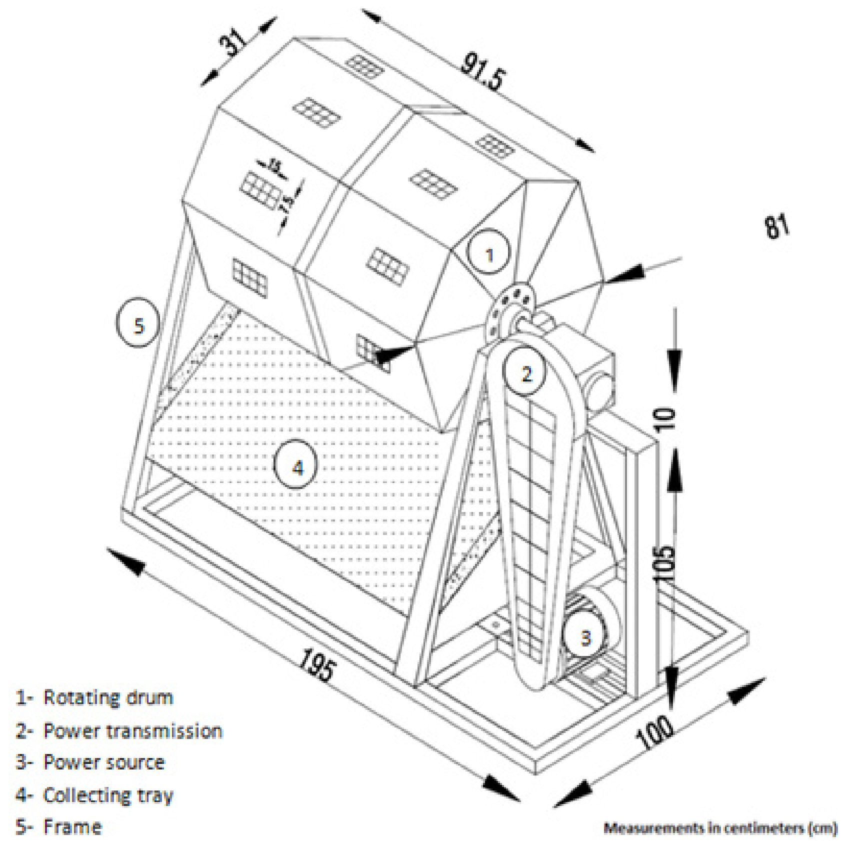

Fig. 1. Schematic diagram of power operated turmeric polisher

continued for 30, 45 and 60 min of polishing. Solar tunnel dried and sun dried turmeric rhizomes were polished separately and the experiment was replicated thrice for each drying method. A two factor completely randomized block design was followed to determine the effect of drying methods on the quality of polished turmeric.

Degree of polish

Degree of polishing or polish percentage is the ratio between the mass of turmeric lost during polishing to that of raw unpolished turmeric and is calculated as proposed by Powar *et al.* (2015).

$$\text{Degree of polish (\%)} = \frac{\text{initial mass of turmeric-final mass of turmeric}}{\text{initial mass of turmeric}} \times 100$$

Quality analysis of polished turmeric

Turmeric rhizomes polished for different time intervals were evaluated for their physical properties like moisture content, colour and bulk density. Moisture content of powdered samples was estimated by toluene method described by ASTA (1968). Color of sample was determined using colour meter (Colorflex EZ, Hunter Lab, 45/0 LAV). The color of the sample was expressed as L*, a* and b* (lightness, hue and chroma of colour) digitally. The information given by L*, a* and b* is generally expressed as total color of the product. The axis –a*, +a* goes from green to red and the axis –b*, +b* goes from blue to yellow. Luminance is vertical axis from black (L*=0) to white (L*=100). Bulk density was determined as the ratio of the mass of the sample to its container volume and was evaluated by weighing the turmeric powder filled in the beaker of known volume (Dhineshkumar and Anandakumar 2016).

Biochemical qualities were estimated in terms of their primary and secondary metabolites. Total carbohydrate was estimated by Anthrone method (Sadasivam and Manickam 2008), protein content was estimated by method described by Lowry *et al.* (1951). The Soxhelet extraction method was used to estimate the total fat content (Sadasivam and Manickam 2008). Essential oil was extracted by hydro- distillation of powdered sample by modified Clevenger method (ASTA 1968) oleoresin content of the turmeric sample was estimated by using the solvent acetone as per the method of ASTA (1968). The curcumin content was estimated as per procedure given by ASTA (1968) using Shimadzu UV-Visible Spectrophotometer (UV-1800) and the absorbance was read at 425 nm against acetone as blank.

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, 30 m × 0.25 mm id × 0.25 μm). The column temperature was programmed as (Injection port temperature: 250˚C, flow rate: 1 ml min^{-1}, carrier gas: helium with linear velocity of 48.1 cm s^{-1}, Split ratio: 50, Ionization energy: 70 eV, Mass range: 40-650 amu).

The quality of dried turmeric, polished for different time intervals were statistically analyzed using AGRES statistical software (Version 7.01, Pascal Intl software solutions).

Results and Discussion

Degree of polish and physical properties of turmeric

The average degree of polish obtained at different time intervals for polishing turmeric dried by the two methods (Table 1) increased as the time interval of polishing increased. For solar tunnel dried turmeric, the degree of polish varied from 3.32% to 9.45% when

Table 1. Variation in physical properties of polished turmeric

Type of drying (D)	Time of polishing min (T)	Degree of polishing (%)	Moisture content, (%)	Colour, L*	Colour a*	Colour b*	Bulk density (kg/m^3)
Solar dried	0	0.00	9.85	42.66	21.27	52.23	238.50
	15	3.32	9.76	44.95	21.72	54.24	317.93
	30	5.45	9.74	45.93	21.76	56.25	321.96
	45	7.38	9.67	46.82	21.56	57.84	323.36
	60	9.45	9.65	47.65	22.90	59.11	329.45
Sun dried	0	0.00	9.89	41.11	20.11	51.84	233.03
	15	3.50	9.80	43.25	20.45	53.22	313.96
	30	5.20	9.75	45.91	20.62	55.90	314.60
	45	7.18	9.71	46.13	20.98	56.96	316.46
	60	9.12	9.70	46.80	21.04	58.30	318.56
				CD (0.05)			
D		0.122^{NS}	0.27^{NS}	0.06**	0.07**	0.03 **	1.46**
T		0.173**	0.43^{NS}	0.09**	0.11**	0.50**	2.31**
D × T		0.169^{NS}	0.62^{NS}	0.13**	0.15**	0.70^{NS}	3.27^{NS}

NS-non significant, **- significant at 1%

the duration of polishing increased from 15 and 60 min, respectively, while for the sun dried turmeric, the corresponding values varied from 3.50 to 9.12%, respectively (Fig. 2 & 3). However, analysis of variance indicated that the drying methods had no significant influence on the degree of polishing but the time of polishing had significant effect on the degree of polishing of turmeric. Pal *et al*. (2008) reported that the farm level turmeric polisher developed by them could achieve a degree of polish of 6% when the polishing drum of capacity 50 kg per batch was rotated below the critical speed of 45 rpm for about 30 min. Moghe *et al*. (2012) reported that the turmeric polishing unit developed by them had a capacity of 50 kg per batch and that the unit could achieve 8% degree of polishing at a speed of 75 rpm in about 20 min. Moisture content of solar tunnel dried and sun dried turmeric varied from 9.65 to 9.89%, respectively. Analysis of variance indicated that there was no significant variation in moisture content due to variation in drying methods, time of polish or due to their interactions.

The initial Hunter colour values L*, a* and b* for solar dried turmeric powder were 42.66, 21.27 and 52.23 respectively and after 60 min of polishing the values increased to 47.65, 22.90 and 59.11 respectively. While that of sun dried turmeric powder, the colour values increased from an initial value of 41.11, 20.11 and 51.84 to the final value of 46.80, 21.04 and 58.30 respectively indicating that the lightness of turmeric powder increased during polishing as

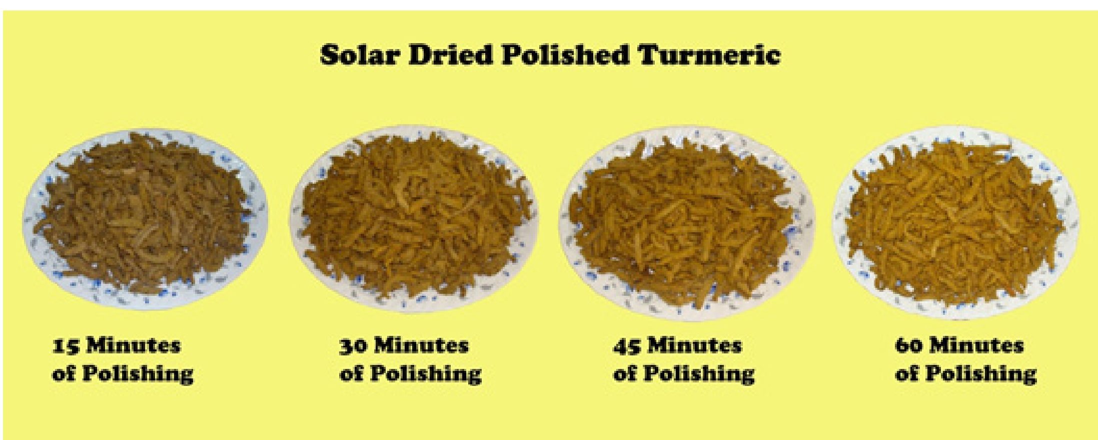

Fig. 2. Solar tunnel dried turmeric after different durations of polishing

Fig. 3. Sun dried turmeric after different durations of polishing

the outer skin was removed. Analysis of variance indicated that there was significant ($p \leq 0.01$) effect on the colour values L*, a* and b* due to variation in drying methods, time of polish and their interactions.

Arora *et al*. (2007) reported that in the rotary drum turmeric washer cum polisher of capacity 100 kg h^{-1}, operated by 1 hp electric motor at optimum conditions of 40 rpm rotational speed for 20 min achieved 7-8% polishing and the color improved from dark yellowish brown to desirable olive yellow color (2.5 YR 6/6, Munsell color chart rating), with increase in the surface smoothness. Singh *et al.* (2010) reported that the Hunter colour values, L*, a* and b* for turmeric powder obtained from finger rhizomes of 'PCT-8' ('Suvarna') variety of turmeric were 45.8, 18.3 and 26.2, respectively and that obtained from mother rhizomes were 47.7, 18.4 and 27.4 respectively at the optimized drying conditions of 60°C temperature and air velocity of 2 m/s. Barnwal *et al*. (2014) studied the selected physico mechanical characteristics of ground turmeric (*cv.* IISR Prabha) for cryogenic and ambient ground turmeric at different moisture contents (4, 6, 8 and 10% w.b.) by grading the powder in to three grades *viz.,* Gr-I, Gr-II and Gr-III with a sieve shaker using BSS Nos. 40, 85 and pan, respectively. The study revealed that the colour values L*, a* and b* for the cryo-ground samples ranged from 54.5, 18.2 and 34.6 (CGr- I, 4% w.b.) to 58.2, 19.4 and 43.6 (CGr-III, 10% w.b.) and for the ambient ground samples it ranged from 51.7, 22.6 72.5 (AGr-I, 4% w.b.) to 60.6, 30.8 and 101.8 (AGr-III, 10% w.b.).

The initial bulk density of the solar dried unpolished turmeric was 238.50 kg/m^3 and after 60 min of polishing the bulk density increased to 329.45 kg/m^3. After polishing there was an increase in bulk density by 38.13%. The bulk density of sun dried unpolished turmeric was 233.03 kg/m^3 and after 60 min of polish it showed 318.56 kg/m^3 with an increase of 36.70% in bulk density. Analysis of variance indicated that the method of drying and time of polish had significant ($p \leq 0.01$) influence on bulk density of polished turmeric but their interactions did not have any significant effect. Moghe *et al.* (2012) studied the physical properties of dried turmeric and reported that the bulk density of dried turmeric varied from 470 to 496 kg/m^3 with an average value of 483 kg/m^3.

Primary and secondary metabolites of polished turmeric

Primary and secondary metabolites of polished turmeric studied (Table 2) indicated that carbohydrate content of solar dried unpolished sample was 68.06% and as the time of polishing progressed from 0 to 60 min, an increase in carbohydrate content to 68.90% was observed. Carbohydrate content of sun dried unpolished turmeric sample was 68.50% and after 60 min of polishing the value increased to 68.93%. Analysis of variance indicated that the drying method, time of polishing and their interactions had significant ($p \leq 0.01$) influence on the carbohydrate content of polished turmeric.

Protein content of solar dried turmeric varied from 3.23 to 3.27% whereas for sun dried turmeric it varied from 3.27 to 3.29% for polishing from 0 to 60 min, respectively. Analysis of variance showed that drying method had significant ($p \leq 0.05$) effect on the protein content, whereas the time of polishing and the interaction between drying method and time of polishing had no significant effect on the protein content of polished turmeric.

Initially, the fat content of unpolished solar dried turmeric sample was 9.36% and after 60 min of polishing, the fat content varied to 9.39%. In case of sun dried turmeric, the fat content varied from 9.38% to 9.39%. Analysis of variance indicated that the method of drying had significant ($p \leq 0.05$) influence on fat content but the time of polish and their interaction did not have significant influence on the fat content of the polished turmeric. Esatbeyoglu *et al*. (2012) reported that dried turmeric rhizomes had average composition of 69.4% of carbohydrates, 13.1% of water; 6.3% of proteins, 5.1% of fats, 3.5% of ash , 2.6% of fibers and the curcuminoids content varied

Table 2. Variation in primary and secondary metabolites of polished turmeric

Type of drying (D)	Time of Polish min (T)	Primary metabolites			Secondary metabolites		
		Carbohydrates (%)	Protein (%)	Fat (%)	Essential oil (%)	Oleoresin (%)	Curcumin (%)
	0	68.06	3.23	9.36	4.00	14.00	6.45
	15	68.47	3.25	9.38	4.00	15.33	6.81
Solar dried	30	68.79	3.26	9.39	4.00	16.00	6.88
	45	68.85	3.26	9.39	4.40	16.00	6.92
	60	68.90	3.27	9.39	4.80	16.00	6.94
	0	68.50	3.27	9.38	4.00	14.00	6.45
	15	68.94	3.28	9.38	4.00	15.00	6.59
Sun dried	30	69.01	3.29	9.38	4.40	15.33	6.65
	45	68.92	3.30	9.39	4.40	16.00	6.75
	60	68.93	3.29	9.39	4.80	16.00	6.91
				CD (0.05)			
D		0.02 **	0.02*	0.01*	0.06**	0.19^{NS}	0.01**
T		0.04 **	0.37^{NS}	0.02^{NS}	0.10**	0.31 **	0.02**
D × T		0.05 **	0.53^{NS}	0.03^{NS}	0.15**	0.43^{NS}	0.02**

NS-non significant, **- significant at 1%, *-significant at 5%

between 2 and 9%, depending on geographic conditions.

The essential oil content was found to increase with the increase in polishing time. The initial essential oil content of unpolished turmeric was 4.0% and after 60 min of polishing the solar and sun dried turmeric showed an essential oil content of 4.80%, which was 20% above the unpolished turmeric sample. Analysis of variance indicated that the drying methods, time of polish and their interactions had significant ($p \leq 0.01$) effect on the essential oil content of the polished turmeric. The oleoresin content of solar and sun dried turmeric showed an increase with the progression in time of polishing. The initial oleoresin content of unpolished turmeric was found to be 14% and the final oleoresin content after 60 min of polish was 16% both in case of solar and sun dried turmeric. There was a relative increase of 14.29% in the oleoresin content of polished turmeric. Analysis of variance indicated that only time of polishing had significant ($p \leq 0.01$) influence on the oleoresin content, however method of drying and the interaction between the two independent variables had no significant influence on the oleoresin content of the polished turmeric.

The curcumin content of solar and sun dried turmeric samples increased with increasing polishing time. The initial curcumin content of solar dried and sun dried unpolished turmeric samples was 6.45%. After 60 min of polishing, the curcumin content increased to 6.94% and 6.91% for solar and sun dried samples with a mean value of 6.79 % and 6.67%, respectively. Analysis of variance indicated that the drying method, time of polishing and their interactions had significant ($p \leq 0.01$) effect on the curcumin content of the polished turmeric.

Jose and Joy (2009) reported the physico-chemical quality of cured turmeric, dried in the solar tunnel drier in comparison to the turmeric dried by conventional and commercial practices followed. The final moisture content values obtained were 12.19% for commercial sample, 11.81% for conventional and 9.98% for solar tunnel dried turmeric. The corresponding essential oil contents increase 4.08%, 4.06% and 4.74% (v/w), respectively with significant variation among the methods. The mean oleoresin contents (wet basis) were 7.89%, 9.36% and 12.44%, respectively, which also showed significant statistical variation. Curcumin content of the solar tunnel-dried sample was 5.83%, whereas for commercial and conventional dried turmeric the values were 4.40 and 4.64%, respectively. Singh *et al*. (2010) reported that the oleoresin content of mechanically dried 'PCT-8' ('Suvarna') variety of turmeric powder, at the optimum drying temperature of 60°C and air velocity of 2 m/s was 13.0% for finger rhizomes and 12.0% for mother rhizomes.

Volatile oil constituents of turmeric oil

The important volatile oil constituents of turmeric oil (Table 3) were turmerone, curlone, ar-turmerone, β-sesquiphellandrene, zingiberene, -phellandrene, caryophyllene, ar-curcumene etc. Turmerone content of solar and sun dried turmeric was found to increase with increase in polishing time. The initial turmerone content of solar dried sample was 25.58% and that of sun dried sample was 21.30%. Upon polishing the turmerone content increased to 28.48% and 27.79%, respectively. Curlone content of solar and sun dried turmeric samples decreased with increasing polishing time. The initial curlone content of unpolished sample was 21.02% and 20.80% respectively. The curlone content decreased to 18.99% and 19.28% respectively upon polishing. Ar-turmerone content of solar and sun dried sample was found to increase with increase in polishing time. The ar-turmerone contents of unpolished turmeric samples solar and sun dried turmeric were 14.59% and 18.74% respectively and increased to 25.42% and 26.25% after polishing for 60 min. Other constituents like ar-curcumene, eucalyptol, cymene and caryophyllene content of turmeric oil were found to increase with increase in polishing time and constituents like α- phellandrene, α-terpinole, zingiberene, and β- sesquiphellandrene content were found

Table 3. Variation in volatile constituents of turmeric oil

Type of drying (D)	Time of polish (T) min	Eucalyptol (%)	Cymene (%)	Caryophyllene (%)	Alpha-Terpineol (%)	Zingiberene (%)	Beta-sesqui-phellandrene (%)	Ar-curcumene (%)	Turmerone (%)	Curlone (%)	Ar-tumer-one (%)	Alpha-phelland-rene (%)
Solar dried	0	0.60	0.41	1.21	0.18	2.63	3.82	1.21	25.58	21.02	14.59	1.75
	15	0.70	0.17	1.72	0.12	2.59	2.79	1.56	27.10	20.92	22.55	2.10
	30	0.45	0.36	1.28	0.01	2.67	4.47	1.72	27.85	19.96	22.65	0.92
	45	0.61	0.49	1.13	0.01	2.52	2.39	1.93	28.05	19.07	24.50	0.56
	60	0.78	0.51	1.32	0.03	2.47	2.62	1.96	28.48	18.99	25.42	1.08
Sun dried	0	0.60	0.46	0.21	0.06	2.45	2.87	2.03	21.30	20.28	18.74	1.78
	15	0.60	0.34	0.64	0.04	2.78	4.94	1.07	26.62	19.43	19.47	1.04
	30	0.59	0.30	0.17	0.04	1.78	2.00	1.99	26.71	19.28	25.54	1.19
	45	0.85	0.53	0.30	0.06	2.67	3.26	2.73	27.74	18.68	25.87	1.68
	60	0.87	0.54	0.32	0.01	2.11	2.90	2.76	27.79	18.28	26.25	1.22
CD (0.05)												
D		0.01**	0.01**	0.03**	0.00**	0.07**	0.10^NS	0.05**	0.82*	0.58**	0.75*	0.04**
T		0.02**	0.17**	0.04**	0.00**	0.11**	0.16**	0.08**	1.30**	0.92**	1.19**	0.06**
D × T		0.02**	0.02**	0.06**	0.00**	0.16**	0.22**	0.12**	1.84**	1.30**	1.69**	0.09**

NS-non significant, **- significant at 1%, *-significant at 5%

to decrease with increase in polishing time. Gounder and 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) reported that the important constituents of the turmeric oil from blanched and unblanched sliced rhizomes and dried in hot air dryer (50±2°C and 58-63% RH) were tumerone, 61.54 and 62.91%; curlone, 27.77 and 25.35%; and cyclohexane, 1.73 and 1.32% respectively.

Optimization of time of polishing for the evaluated turmeric polisher was done based on the physical appearance of turmeric after polishing. The criteria followed was reasonably good appearance as preferred in the market and minimum loss in mass during polishing. Considering these two factors, it could be summarized that polishing of turmeric for 30 min was considered optimum to obtain turmeric rhizomes of good appearance and the degree of polishing for solar tunnel dried turmeric was 5.45% and that of sun dried turmeric was 5.20%.

To summarize, solar tunnel dried and sun dried turmeric rhizomes were polished separately in a power operated turmeric polisher for different time intervals varying from 15 min to 60 min. The degree of polishing obtained after 60 min of polishing turmeric dried in solar tunnel drier was 9.45% and for sun dried turmeric was 9.12%. Studies on the quality of turmeric indicated that the relative quality of polished turmeric was found to increase with the increase in polishing time. However, based upon the visual acceptance of turmeric after polishing and minimum loss in weight during polishing it could be concluded that in the studied turmeric polisher, polishing of turmeric for 30 min was optimum and the degree of polishing for solar tunnel dried turmeric was 5.45% and that of sun dried turmeric was 5.20%.

References

Arora M, Sehgal V K & Sharma S R 2007 Quality evaluation of mechanically washed and polished turmeric rhizomes. J Agric. Eng. 44(2): 39–43.

ASTA 1968 Official Analytical Methods of the American Spice Trade Association (2nd Edn) New Jersey.

Barnwal Pradyuman, Ashish M Mohite1, Krishna K Singh & Pankaj Kumar 2014 Selected physico-mechanical characteristics of cryogenic and ambient ground turmeric. Int. Agrophys. 28(1): 111–117.

Dhineshkumar V & Anandakumar S 2016 Physical and engineering properties of turmeric rhizome. South Asian J. Food Technol. Environ. 2(1): 304–308.

Esatbeyoglu T, Huebbe P, Ernst I M, Chin D, Wagner A E & Rimbach G 2012 Curcumin-from molecule to biological function. Angewandte Chemie International Edition. 51(22): 5308–5332.

Gounder D K & Lingamallu, J 2012 Comparison of chemical composition and antioxidant potential of volatile oil from fresh, dried and cured turmeric *(Curcuma longa*) rhizomes, Ind. Crops Prod. 38: 124–131.

Hoque M A & Hossain M A 2018 Design and development of a turmeric polisher, J Bangladesh Agric. Univ. 16(2): 303–308.

Jose K P & Joy C M 2009 Solar tunnel drying of turmeric (*Curcuma longa* Linn. syn. c. domestica val.) for quality improvement. J. Food Process. Preserv. 33(1): 121–135.

Lowry O H, Rosebrough N J, Farr A L, & Randall R J 1951 Protein measurement with the Folin phenol reagent, J. Biol. Chem. 193(1): 265–275.

Moghe S M, Zakiuddin K S & Arajpure V G 2012 Design and development of turmeric polishing machine, Int. J. Mod. Eng. Res. 2(6): 4710–4713.

Pal U S, Khan K, Sahoo N R & Sahoo G 2008 Development and Evaluation of Farm Level Turmeric Processing Equipment, AMA Agric. Mech. Asia Afr. Lat. Am. 39: 46–50.

Powar R V, Patil S B & Bandgar P S 2015 Comparitive evaluation of different types of polisher. Int. J. Agric. Biol. Eng. 8(1): 127–131.

Pradeep K, Ravi R, Jamuna Prakash & Madhava Naidu M 2016 Influence of blanching and drying methods on the quality characteristics of fresh turmeric (*Curcuma longa* L.) rhizomes. Int. J. Appl. Pure Sci.and Agri. 2(1): 32–44.

Sadasivam S & Manickam A 2008 Biochemical Methods for Agricultural Sciences (6th Ed.), New Age International (P) Limited, New Delhi.

Ravindran P N, Babu K N & Sivaraman K 2007 The genus Curcuma pp. 257–296.

Singh Gursewak, Sadhna Arora & Satish Kumar 2010 Effect of mechanical drying air conditions on quality of turmeric powder. J. Food Sci. Technol. 47(3): 347–350.

Spices Board 2022 http://www.indianspices.com/sites/default/files/majorspicewise2021.pdf

Sukumaran C R & Satyanarayana C H 1999 Souvenir cum- Proceedings of the national seminar on Food Processing. Challenges and Opportunities, Gujrat Agricultural University, Anand.

Viswanathan R, Devadas C T & Sreenarayanan V V 2002 Farm level steam boiling of turmeric rhizomes. Spice India 15: 2-4.