



## Effect of pre treatments and methods of blanching on the quality of turmeric

(Manuscript Received: 20-09-08, Revised: 18-04-09, Accepted: 20-09-09)

**Keywords:** Blanching, curcumin, essential oil, oleoresin, Turmeric

Turmeric is one of the important spice and cash crops of India and a traditional item of export. It forms an important adjunct in Indian culinary as it lends colour and aromatic flavour to various dishes (Pujari *et al.*, 1986). Apart from its use in preparation of tasty dishes, it is also used widely in processed food, cotton textiles, medicines and cosmetics (Pal *et al.*, 2003). Turmeric rhizome (*Curcuma longa*, L.) is one of the most important natural sources of yellow coloring. The pigments responsible for the yellow color characteristic of the oleoresin in turmeric are the curcuminoids, curcumin, desmethoxy-curcumin and bis-desmethoxy-curcumin. These pigments are largely used in the food industry as substitutes for synthetic dyes like tartrazin. Curcumin is a yellow-orange crystalline powder, insoluble in water and ether but soluble in low-chain alcohols such as ethanol and methanol, acetone, acetic acid and dichloromethane (Chassagnez-Mendez *et al.*, 2000). Curcumin and oleoresin help in lowering the total cholesterol in the blood serum (Hanumanthappa Manjunatha and Krishnapura Srinivasan, 2008).

Though, India is the largest producer and exporter of turmeric, only four per cent of the turmeric produced is exported. Turmeric processing involves two main steps, blanching and drying. Blanching prior to drying increased the process rate at all the temperatures tested, although its effect was reduced when the air drying temperature increased (Blasco, 2006). The final quality and the rate of drying of turmeric depend on the method of blanching. There is need to produce high quality turmeric which could fetch good demand and prices in the world market. Hence, experiments were conducted with three varieties of turmeric viz., BSR I, BSR II and Erode local, by various pre-treatments using cow dung slurry (to increase

boiling point), soda and with water alone and by different methods of blanching like conventional, steam cooking and pressure cooking under different pressure ranging from 0.5 to 1 kg/cm<sup>2</sup> and for duration ranging from 5 to 15 min. The effect of various pre-treatment and methods of blanching on curcumin, oleoresin and essential oil was studied.

Finger rhizomes of three turmeric varieties (BSR I, BSR II and Erode local) obtained from the Agricultural Research Station, Bhavanisagar were used for the experiment. Duration of growth for varieties was 280 days for BSR I, 250 days for BSR II and 270 days for Erode local. The rhizomes were washed and cleaned before the experiment and loaded in a container and water was filled and about 20 g of sodium bicarbonate was added. The container was closed with a gunny bag which was dipped in cowdung slurry. The boiling lasted from 50 min. to 1 hr. Five ml castor oil was added (to increase boiling point), when the water spilt out during boiling. Completion of cooking was judged by fumes and fragrance of turmeric as well as by piercing midrib of coconut leaflet. Soon after boiling, the rhizomes were heaped in the field to drain water and they were not disturbed till the next day to avoid breakage of fingers. The next day rhizomes were spread evenly in the field to dry. The drying lasted for a period of about 20-25 days till the moisture content came down to about 10 per cent.

The study on boiling of turmeric in open steam was conducted using lab model TNAU (Tamil Nadu Agricultural University) paddy parboiling drum. Four liters of water was poured into the drum and the steam distributor was placed inside the unit. The heater was set at 80°C. Two kg turmeric rhizomes were put in between the pipes of the steam distributor and covered with the

lid. The rhizomes were boiled for different durations of 15, 25 and 35 min with (0.2 g) and without sodium bicarbonate (baking soda). After steaming, the hot rhizomes were spread in the drying floor.

Pressure boiling of turmeric rhizome was done in an autoclave. The steam pressure was measured by pressure gauge and controlled by the valve. Two kg of turmeric was subjected to pressure boiling. The raise in steam pressure was noted and maintained at the required level by adjusting the pressure valve. At the end of steaming, the spent steam was released through the outlet. The lid was opened and sample removed and weighed. The rhizomes were boiled at various pressure (0.5, 0.75 and 1 kg/cm<sup>2</sup>) and durations (5, 10, 15 min).

The rhizomes after boiling were spread uniformly in the aluminum trays and were dried from 8.30 am to 4.30 pm for 15 days depending on the intensity of sun light. The samples were weighed at regular intervals. The temperature ranged from 29 to 34° C during sun drying.

In the mechanical drying method, rhizomes were dried in cross flow drier. The drying study was carried out at 60° C. This temperature was chosen from the earlier studies conducted for air drying of turmeric (Praditdoun *et al.*, 1996). The drier was run for 1 hr in order to stabilize the chamber temperature to 60° C before the commencement of the experiment. The drying conditions were kept constant for all the commencement of the experiments. Drying was terminated when the moisture content of the samples reached 8-10 per cent.

The samples were weighed at regular intervals and stored for further studies.

Curcumin, oleoresin and essential oil in processed turmeric were estimated as per AOAC standards (Rangana, 2004).

Table-1 shows the effect of different methods of boiling and drying on the oleoresin content of turmeric. When the experiment was conducted by conventional methods, the water left out after boiling was yellow in colour, showing that some amount of curcumin (1.12 %), oleoresin (4.62 %) and essential oil (5.3 %) have leached into water. Whereas in the open steam and pressure boiling, there was no change in water colour after boiling. Boiling the rhizomes with soda (sodium bicarbonate) changed the colour of rhizomes to red, and showed the lowest oleoresin content. The oleoresin, curcumin and essential oil content were high when the turmeric was processed immediately after harvest compared with the stored rhizome irrespective of varieties tested. The result is in agreement with that of Goyal and Kurla (1993).

The oleoresin content was high in BSR II (5.67 %) when compared to BSR I (3.35 %) and Erode local (5.64 %). The oleoresin content was maximum when the rhizome was boiled at 0.5 kg/cm<sup>2</sup> pressure for the duration of 5 to 15 min for all the varieties. The lower amount of oleoresin in the conventional process may be due to leaching of some quantity of oleoresin during the boiling process (4.62 %). In the pressure boiled process, the oleoresin content decreased as the pressure increased.

**Table 1. Effect of different methods of boiling and drying on the oleoresin content of turmeric**

Treatments	Sun drying			Mechanical drying		
	BSRI	BSRII	Erode Local	BSRI	BSRII	Erode Local
Turmeric + cow dung	3.020 ± 0.002 <sup>b</sup>	5.630 ± 0.003 <sup>d</sup>	5.595 ± 0.002 <sup>e</sup>	3.080 ± 0.002 <sup>f</sup>	5.840 ± 0.003 <sup>a</sup>	5.602 ± 0.002 <sup>e</sup>
Turmeric + sodiumbicarbonate	2.810 ± 0.003 <sup>a</sup>	5.30 ± 0.003 <sup>b</sup>	5.206 ± 0.002 <sup>g</sup>	2.910 ± 0.002 <sup>j</sup>	5.430 ± 0.003 <sup>c</sup>	5.602 ± 0.002 <sup>e</sup>
Turmeric + water	3.200 ± 0.002 <sup>f</sup>	5.620 ± 0.003 <sup>e</sup>	5.208 ± 0.001 <sup>g</sup>	3.009 ± 0.002 <sup>g</sup>	5.820 ± 0.003 <sup>c</sup>	5.403 ± 0.002 <sup>g</sup>
Open steam 15 min	3.230 ± 0.003 <sup>e</sup>	5.640 ± 0.003 <sup>c</sup>	5.622 ± 0.002 <sup>d</sup>	3.340 ± 0.003 <sup>c</sup>	5.810 ± 0.003 <sup>c</sup>	5.625 ± 0.002 <sup>d</sup>
Open steam 25 min	3.245 ± 0.002 <sup>d</sup>	5.650 ± 0.002 <sup>b</sup>	5.623 ± 0.002 <sup>d</sup>	3.320 ± 0.003 <sup>c</sup>	5.830 ± 0.003 <sup>b</sup>	5.731 ± 0.002 <sup>c</sup>
Open steam 35 min	3.200 ± 0.002 <sup>f</sup>	5.650 ± 0.002 <sup>b</sup>	5.622 ± 0.002 <sup>d</sup>	3.330 ± 0.003 <sup>d</sup>	5.840 ± 0.003 <sup>a</sup>	5.738 ± 0.001 <sup>a</sup>
Open steam with soda 15 min	2.945 ± 0.002 <sup>i</sup>	5.410 ± 0.003 <sup>g</sup>	5.215 ± 0.002 <sup>f</sup>	2.980 ± 0.002 <sup>i</sup>	5.440 ± 0.003 <sup>g</sup>	5.738 ± 0.001 <sup>a</sup>
Open steam with soda 25 min	2.955 ± 0.002 <sup>k</sup>	5.430 ± 0.002 <sup>f</sup>	5.214 ± 0.002 <sup>f</sup>	2.990 ± 0.003 <sup>h</sup>	5.450 ± 0.004 <sup>f</sup>	5.411 ± 0.002 <sup>f</sup>
Open steam with soda 35 min	2.805 ± 0.001 <sup>o</sup>	5.430 ± 0.002 <sup>f</sup>	5.214 ± 0.002 <sup>f</sup>	2.990 ± 0.003 <sup>h</sup>	5.460 ± 0.003 <sup>c</sup>	5.411 ± 0.002 <sup>f</sup>
Pressure 0.5 kg/cm <sup>2</sup> 5 min	3.355 ± 0.002 <sup>a</sup>	5.650 ± 0.002 <sup>b</sup>	5.643 ± 0.002 <sup>b</sup>	3.350 ± 0.003 <sup>b</sup>	5.840 ± 0.003 <sup>a</sup>	5.412 ± 0.002 <sup>f</sup>
Pressure 0.5 kg/cm <sup>2</sup> 10 min	3.325 ± 0.002 <sup>b</sup>	5.670 ± 0.003 <sup>a</sup>	5.644 ± 0.002 <sup>b</sup>	3.350 ± 0.003 <sup>b</sup>	5.840 ± 0.003 <sup>a</sup>	5.738 ± 0.002 <sup>a</sup>
Pressure 0.5 kg/cm <sup>2</sup> 15 min	3.325 ± 0.002 <sup>b</sup>	5.670 ± 0.003 <sup>a</sup>	5.643 ± 0.002 <sup>b</sup>	3.360 ± 0.003 <sup>a</sup>	5.840 ± 0.003 <sup>a</sup>	5.738 ± 0.002 <sup>a</sup>
Pressure 0.75 kg/cm <sup>2</sup> 5 min	3.300 ± 0.003 <sup>c</sup>	5.670 ± 0.003 <sup>a</sup>	5.643 ± 0.002 <sup>b</sup>	3.350 ± 0.003 <sup>b</sup>	5.840 ± 0.003 <sup>a</sup>	5.738 ± 0.002 <sup>a</sup>
Pressure 0.75 kg/cm <sup>2</sup> 10 min	3.200 ± 0.002 <sup>f</sup>	5.650 ± 0.002 <sup>b</sup>	5.643 ± 0.002 <sup>b</sup>	3.350 ± 0.003 <sup>b</sup>	5.830 ± 0.003 <sup>b</sup>	5.737 ± 0.001 <sup>ab</sup>
Pressure 0.75 kg/cm <sup>2</sup> 15 min	3.195 ± 0.002 <sup>g</sup>	5.650 ± 0.002 <sup>b</sup>	5.643 ± 0.002 <sup>b</sup>	3.340 ± 0.003 <sup>c</sup>	5.830 ± 0.003 <sup>b</sup>	5.737 ± 0.001 <sup>ab</sup>
Pressure 1 kg/cm <sup>2</sup> 5 min	3.005 ± 0.002 <sup>i</sup>	5.650 ± 0.002 <sup>b</sup>	5.639 ± 0.002 <sup>bc</sup>	3.340 ± 0.003 <sup>c</sup>	5.830 ± 0.003 <sup>b</sup>	5.737 ± 0.001 <sup>ab</sup>
Pressure 1 kg/cm <sup>2</sup> 10 min	2.99 ± 0.003 <sup>j</sup>	5.650 ± 0.002 <sup>b</sup>	5.642 ± 0.002 <sup>bc</sup>	3.340 ± 0.003 <sup>c</sup>	5.830 ± 0.003 <sup>b</sup>	5.735 ± 0.001 <sup>2b</sup>
Pressure 1 kg/cm <sup>2</sup> 15 min	2.905 ± 0.002 <sup>m</sup>	5.650 ± 0.002 <sup>b</sup>	5.649 ± 0.002 <sup>a</sup>	3.340 ± 0.003 <sup>c</sup>	5.830 ± 0.003 <sup>b</sup>	5.735 ± 0.001 <sup>2b</sup>

Mean ± S.D, n = 3, Values in same column with different superscripts differ significantly (P ≤ 0.05)

Elevation of the temperature of steam at higher pressure (0.75 and 1.0 kg/cm<sup>2</sup>) may influence the evaporation of oleoresin. There is no change in oleoresin content in open steam boiling, since the temperature of rhizomes was not increased above 94° C. The oleoresin content was higher (3.36 %) in mechanically dried rhizomes than in sun dried rhizomes (3.35 %). It may be due to exposure of rhizomes for longer time under the sun. The oleoresin content of rhizomes boiled under pressure and dried in mechanical drier was more than the conventional method.

Table 2 shows the effect of different methods of boiling and drying on the curcumin content of turmeric. Boiling turmeric with sodium bicarbonate in conventional method showed the highest loss in curcumin. The curcumin content in BSR II was the lowest due to the varietal character. Increase in the time of boiling in open steam method did not show significant difference in the curcumin content. Increase in the pressure during pressure boiling showed a slight decline in the curcumin content. The curcumin content was high when rhizome was boiled at 0.5 kg/cm<sup>2</sup> pressure for 5 to 15 min. for all the varieties tested. There was a significant decrease in curcumin with increase in pressure. Mechanical method of drying showed higher amount of curcumin in all the treatments. Boiling turmeric with sodium bicarbonate showed the lowest amount of

curcumin in all the varieties tested, the reduction in curcumin content ranged from 8 to 9 %. Sampathu *et al.* (1988) also reported reduction in curcumin content.

Table 3 shows the effect of different methods of boiling and drying on essential oil content of turmeric. The essential oil content was high in Erode local (4.5 %) when compared to BSR I (3.5 %) and BSR II (1.5 %). Turmeric boiled with sodium bicarbonate showed the lowest amount of essential oil in all the methods of boiling and in all the varieties tested. The essential oil content was high when the rhizomes were boiled at 0.5 kg/cm<sup>2</sup> pressure for the duration of 5 to 15 min. for all the varieties tested. The decrease in the essential oil content in the conventional processing is due to the leaching of oil in water. In the pressure boiled process, the essential oil content decreased as the pressure was increased. There was no change in essential oil content in open steam boiling, since the temperature of the rhizomes was not increased above 94° C. The essential oil content was higher (3.9 %) in mechanically dried rhizomes than in sun dried rhizomes (3.75 %). It may be due to exposure of rhizomes for longer time under the sun. The essential oil content of rhizomes boiled under pressure and dried in mechanical drier was more than the conventional method.

Among the processing treatments compared, boiling rhizomes at a pressure of 0.5 kg/cm<sup>2</sup> for duration

**Table 2. Effect of different methods of boiling and drying on the curcumin content of turmeric (%)**

Treatments	Sun drying			Mechanical drying		
	BSRI	BSRII	Erode Local	BSRI	BSRII	Erode Local
Turmeric + cow dung	3.960 ± 0.003 <sup>e</sup>	2.908 ± 0.001 <sup>f</sup>	3.035 ± 0.002 <sup>j</sup>	4.030 ± 0.001 <sup>f</sup>	2.916 ± 0.001 <sup>b</sup>	3.082 ± 0.001 <sup>g</sup>
Turmeric + sodium bicarbonate	3.63 ± 0.003 <sup>k</sup>	2.785 ± 0.002 <sup>h</sup>	2.960 ± 0.003 <sup>o</sup>	3.820 ± 0.002 <sup>i</sup>	2.804 ± 0.001 <sup>f</sup>	2.994 ± 0.001 <sup>i</sup>
Turmeric + water	3.975 ± 0.002 <sup>d</sup>	2.943 ± 0.001 <sup>d</sup>	3.070 ± 0.004 <sup>f</sup>	4.050 ± 0.003 <sup>c</sup>	2.920 ± 0.001 <sup>a</sup>	3.174 ± 0.001 <sup>e</sup>
Open steam 15 min	4.025 ± 0.001 <sup>a</sup>	2.995 ± 0.001 <sup>a</sup>	3.130 ± 0.003 <sup>a</sup>	4.090 ± 0.001 <sup>b</sup>	2.301 ± 0.001 <sup>g</sup>	3.208 ± 0.001 <sup>b</sup>
Open steam 25 min	4.015 ± 0.002 <sup>b</sup>	2.989 ± 0.002 <sup>ab</sup>	3.125 ± 0.002 <sup>b</sup>	4.090 ± 0.001 <sup>b</sup>	2.301 ± 0.001 <sup>g</sup>	3.209 ± 0.001 <sup>ab</sup>
Open steam 35 min	3.975 ± 0.003 <sup>d</sup>	2.987 ± 0.002 <sup>ab</sup>	3.100 ± 0.003 <sup>d</sup>	4.080 ± 0.001 <sup>c</sup>	2.302 ± 0.001 <sup>g</sup>	3.209 ± 0.001 <sup>ab</sup>
Open steam with soda 15 min	3.665 ± 0.001 <sup>j</sup>	2.834 ± 0.001 <sup>g</sup>	2.985 ± 0.001 <sup>m</sup>	3.910 ± 0.001 <sup>h</sup>	2.806 ± 0.001 <sup>c</sup>	2.998 ± 0.001 <sup>h</sup>
Open steam with soda 25 min	3.665 ± 0.001 <sup>j</sup>	2.832 ± 0.001 <sup>g</sup>	2.990 ± 0.004 <sup>l</sup>	3.920 ± 0.002 <sup>g</sup>	2.807 ± 0.001 <sup>c</sup>	2.998 ± 0.001 <sup>h</sup>
Open steam with soda 35 min	3.665 ± 0.001 <sup>j</sup>	2.830 ± 0.01 <sup>g</sup>	2.975 ± 0.001 <sup>n</sup>	3.910 ± 0.002 <sup>a</sup>	2.808 ± 0.001 <sup>c</sup>	2.998 ± 0.001 <sup>h</sup>
Pressure 0.5 kg/cm <sup>2</sup> 5 min	4.020 ± 0.007 <sup>a</sup>	2.994 ± 0.001 <sup>a</sup>	3.125 ± 0.001 <sup>b</sup>	4.110 ± 0.002 <sup>a</sup>	2.808 ± 0.001 <sup>c</sup>	3.210 ± 0.001 <sup>a</sup>
Pressure 0.5 kg/cm <sup>2</sup> 10 min	3.975 ± 0.001 <sup>d</sup>	2.944 ± 0.03 <sup>b</sup> <sup>c</sup>	3.060 ± 0.004 <sup>g</sup>	4.110 ± 0.001 <sup>a</sup>	2.809 ± 0.001 <sup>c</sup>	3.210 ± 0.001 <sup>a</sup>
Pressure 0.5 kg/cm <sup>2</sup> 15 min	3.935 ± 0.001 <sup>f</sup>	2.966 ± 0.001 <sup>c</sup>	3.055 ± 0.002 <sup>h</sup>	4.100 ± 0.007 <sup>a</sup>	2.809 ± 0.001 <sup>c</sup>	3.209 ± 0.001 <sup>ab</sup>
Pressure 0.75 kg/cm <sup>2</sup> 5 min	3.985 ± 0.001 <sup>c</sup>	2.939 ± 0.001 <sup>d</sup>	3.105 ± 0.002 <sup>c</sup>	4.080 ± 0.002 <sup>c</sup>	2.809 ± 0.001 <sup>c</sup>	3.209 ± 0.001 <sup>ab</sup>
Pressure 0.75 kg/cm <sup>2</sup> 10 min	3.900 ± 0.002 <sup>g</sup>	2.939 ± 0.001 <sup>d</sup>	3.100 ± 0.003 <sup>d</sup>	4.080 ± 0.002 <sup>c</sup>	2.808 ± 0.001 <sup>c</sup>	3.209 ± 0.001 <sup>ab</sup>
Pressure 0.75 kg/cm <sup>2</sup> 15 min	3.900 ± 0.002 <sup>g</sup>	2.940 ± 0.001 <sup>d</sup>	3.083 ± 0.002 <sup>e</sup>	4.070 ± 0.002 <sup>d</sup>	2.808 ± 0.001 <sup>c</sup>	3.108 ± 0.001 <sup>f</sup>
Pressure 1 kg/cm <sup>2</sup> 5 min	3.895 ± 0.001 <sup>h</sup>	2.925 ± 0.001 <sup>e</sup>	3.044 ± 0.003 <sup>i</sup>	4.050 ± 0.003 <sup>c</sup>	2.808 ± 0.001 <sup>c</sup>	3.200 ± 0.001 <sup>d</sup>
Pressure 1 kg/cm <sup>2</sup> 10 min	3.845 ± 0.001 <sup>i</sup>	2.922 ± 0.001 <sup>e</sup>	3.043 ± 0.002 <sup>i</sup>	4.050 ± 0.003 <sup>c</sup>	2.808 ± 0.001 <sup>c</sup>	3.204 ± 0.001 <sup>c</sup>
Pressure 1 kg/cm <sup>2</sup> 15 min	3.845 ± 0.001 <sup>i</sup>	2.922 ± 0.001 <sup>e</sup>	3.015 ± 0.002 <sup>k</sup>	4.050 ± 0.003 <sup>c</sup>	2.807 ± 0.001 <sup>ce</sup>	3.204 ± 0.001 <sup>c</sup>

Mean ± S.D, n = 3, Values in same column with different superscripts differ significantly (P = 0.05)

**Table 3. Effect of different methods of boiling and drying on the essential oil content of turmeric**

Treatments	Sun drying			Mechanical drying		
	BSRI	BSRII	Erode Local	BSRI	BSRII	Erode Local
Turmeric + cow dung	3.505 ± 0.002 <sup>i</sup>	1.530 ± 0.002 <sup>d</sup>	4.330 ± 0.002 <sup>j</sup>	3.540 ± 0.003 <sup>i</sup>	1.580 ± 0.002 <sup>f</sup>	4.450 ± 0.003 <sup>g</sup>
Turmeric + sodium bicarbonate	3.415 ± 0.002 <sup>j</sup>	1.420 ± 0.002 <sup>e</sup>	4.155 ± 0.001 <sup>n</sup>	3.500 ± 0.003 <sup>j</sup>	1.460 ± 0.002 <sup>j</sup>	4.200 ± 0.002 <sup>k</sup>
Turmeric + water	3.550 ± 0.003 <sup>h</sup>	1.530 ± 0.003 <sup>d</sup>	4.355 ± 0.001 <sup>i</sup>	3.580 ± 0.001 <sup>h</sup>	1.590 ± 0.002 <sup>e</sup>	4.420 ± 0.002 <sup>h</sup>
Open steam 15 min	3.740 ± 0.003 <sup>e</sup>	1.532 ± 0.001 <sup>d</sup>	4.515 ± 0.001 <sup>e</sup>	3.900 ± 0.002 <sup>c</sup>	1.620 ± 0.002 <sup>d</sup>	4.520 ± 0.002 <sup>d</sup>
Open steam 25 min	3.720 ± 0.002 <sup>d</sup>	1.538 ± 0.001 <sup>c</sup>	4.550 ± 0.001 <sup>a</sup>	3.900 ± 0.002 <sup>c</sup>	1.620 ± 0.002 <sup>d</sup>	4.560 ± 0.002 <sup>a</sup>
Open steam 35 min	3.740 ± 0.003 <sup>e</sup>	1.539 ± 0.002 <sup>abc</sup>	4.545 ± 0.001 <sup>b</sup>	3.900 ± 0.002 <sup>c</sup>	1.630 ± 0.003 <sup>c</sup>	4.560 ± 0.002 <sup>a</sup>
Open steam with soda 15 min	3.125 ± 0.001 <sup>m</sup>	1.430 ± 0.002 <sup>f</sup>	4.230 ± 0.002 <sup>m</sup>	3.500 ± 0.002 <sup>j</sup>	1.520 ± 0.003 <sup>g</sup>	4.250 ± 0.003 <sup>j</sup>
Open steam with soda 25 min	3.330 ± 0.001 <sup>k</sup>	1.440 ± 0.003 <sup>e</sup>	4.235 ± 0.001 <sup>l</sup>	3.450 ± 0.003 <sup>k</sup>	1.510 ± 0.002 <sup>h</sup>	4.250 ± 0.003 <sup>j</sup>
Open steam with soda 35 min	3.320 ± 0.002 <sup>l</sup>	1.440 ± 0.003 <sup>e</sup>	4.250 ± 0.003 <sup>k</sup>	3.450 ± 0.003 <sup>k</sup>	1.500 ± 0.002 <sup>i</sup>	4.260 ± 0.002 <sup>j</sup>
Pressure 0.5 kg/cm <sup>2</sup> 5 min	3.750 ± 0.003 <sup>a</sup>	1.540 ± 0.003 <sup>a</sup>	4.530 ± 0.003 <sup>c</sup>	3.930 ± 0.003 <sup>b</sup>	1.630 ± 0.002 <sup>c</sup>	4.560 ± 0.002 <sup>a</sup>
Pressure 0.5 kg/cm <sup>2</sup> 10 min	3.745 ± 0.006 <sup>b</sup>	1.542 ± 0.002 <sup>ab</sup>	4.545 ± 0.001 <sup>b</sup>	3.930 ± 0.003 <sup>b</sup>	1.650 ± 0.003 <sup>a</sup>	4.560 ± 0.002 <sup>a</sup>
Pressure 0.5 kg/cm <sup>2</sup> 15 min	3.700 ± 0.001 <sup>f</sup>	1.542 ± 0.002 <sup>ab</sup>	4.545 ± 0.001 <sup>b</sup>	3.940 ± 0.003 <sup>a</sup>	1.650 ± 0.003 <sup>a</sup>	4.560 ± 0.002 <sup>a</sup>
Pressure 0.75 kg/cm <sup>2</sup> 5 min	3.745 ± 0.001 <sup>bc</sup>	1.540 ± 0.003 <sup>a</sup>	4.545 ± 0.001 <sup>b</sup>	3.750 ± 0.003 <sup>c</sup>	1.650 ± 0.003 <sup>a</sup>	4.540 ± 0.003 <sup>b</sup>
Pressure 0.75 kg/cm <sup>2</sup> 10 min	3.705 ± 0.001 <sup>e</sup>	1.540 ± 0.003 <sup>a</sup>	4.530 ± 0.003 <sup>c</sup>	3.800 ± 0.002 <sup>d</sup>	1.650 ± 0.003 <sup>a</sup>	4.540 ± 0.003 <sup>b</sup>
Pressure 0.75 kg/cm <sup>2</sup> 15 min	3.705 ± 0.001 <sup>e</sup>	1.539 ± 0.001 <sup>bc</sup>	4.520 ± 0.002 <sup>d</sup>	3.800 ± 0.002 <sup>d</sup>	1.650 ± 0.003 <sup>a</sup>	4.530 ± 0.002 <sup>c</sup>
Pressure 1 kg/cm <sup>2</sup> 5 min	3.700 ± 0.002 <sup>f</sup>	1.539 ± 0.001 <sup>bc</sup>	4.505 ± 0.002 <sup>f</sup>	3.800 ± 0.002 <sup>d</sup>	1.640 ± 0.003 <sup>b</sup>	4.510 ± 0.002 <sup>e</sup>
Pressure 1 kg/cm <sup>2</sup> 10 min	3.700 ± 0.002 <sup>f</sup>	1.539 ± 0.001 <sup>bc</sup>	4.495 ± 0.002 <sup>g</sup>	3.700 ± 0.002 <sup>f</sup>	1.640 ± 0.003 <sup>b</sup>	4.5315 ± 0.002 <sup>c</sup>
Pressure 1 kg/cm <sup>2</sup> 15 min	3.650 ± 0.003 <sup>g</sup>	1.539 ± 0.001 <sup>bc</sup>	4.490 ± 0.002 <sup>h</sup>	3.600 ± 0.002 <sup>g</sup>	1.640 ± 0.003 <sup>b</sup>	4.500 ± 0.003 <sup>f</sup>

Mean ± S.D, n = 3, Values in same column with different superscripts differ significantly (P = 0.05)

of 5 to 15 min. showed the highest percent of curcumin, oleoresin and essential oil when compared with the other methods of boiling. Drying the rhizomes in mechanical drier showed the highest percent of curcumin, oleoresin and essential oil content than drying under sun.

### References

- AOAC.1975. Official methods of analysis. *Association of official analytical chemists*, Benjamin Franklin station, Washington, 563.
- Blasco, M., Garcia-Peerez. J.V., Bon. J., Carreres.J.E and Mulet. A. 2006. Effect of blanching and air flow rate on turmeric drying. *Food Science and Technology International*. **12**(4): 315-323.
- Chassagnez-Mendez, L., Correa, N. C. F., Franca. L. F., Machado, N. T. and Araujo. M. E. 2000. A mass transfer model applied to the supercritical extraction with CO<sub>2</sub> of curcumins from turmeric rhizomes (*Curcuma longa* L). *Brazilian Journal of Chemical Engineering* **17**: 315-322.
- Goyal, P.K. and Kurla. R.N. 1993. Changes in the quality of turmeric rhizomes during storage. *Journal of Food Science and Technology* **30**(5): 362-364.
- Hanumanthappa Manjunatha and Krishnapura Srinivasan. 2008. Hypolipidemic and antioxidant potency of heat processed turmeric and red pepper in experimental rats. *African Journal of Food Science* **2**(1): 001-006.
- National Research Center for Spices. 1991. Turmeric. *Spice India*. **4**(7): 2-5.
- Pal, U.S., Khan, M.K., Sahoo G.R and Panda, M.K. 2003. Post-harvest practices of turmeric in Orissa, India, *Agric Mech Asia Afr Lat Am*. **34**(4): 45-49.
- Praditdoug. P., Kaeumanae, W., Ganjanagoonchorn and Ianichgarnjanakul, K. 1996. Effect of curing on turmeric tissue and drying time. *J. Natural Science* **30**(4): 485-592.
- Pujari, R.B. Patil and Satpal, R.T.1986. 'Krishna' A high yielding variety of turmeric. *Indian Cocoa, Arecanut and Spices J*. **9**(3): 65-66.
- Rangana, S. 2004. Handbook of analysis and quality control of fruits and vegetables products. Tata McGraw-Hill Publication, New Delhi. pp. 264-269.
- Sampathu, S.R., Krishnamurthy, N., Sowbhagya, H.B. and Shankaranarayana, M.L. 1998. Studies on quality of turmeric (*Curcuma longa*) in relation to curing methods. *J. of Food Science and Technology* **25**(3): 152-155.