

## Nutritional analysis of *Curcuma longa L.* in different cities of west uttar Pradesh (INDIA)

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### ABSTRACT

Turmeric *Curcuma longa L.* of Zingiberaceae family is a widely cultivated in India and other Asian countries. Turmeric is rich in curcuminoids, consists of a mixture of three curcuminoids, namely, curcumin, demethoxycurcumin, and bisdemethoxycurcumin. These were isolated by column chromatography and identified by <sup>1</sup>H NMR. The nutritional value, proximate analysis, vitamins and amino acid composition *curcuma longa L.* cultivated in three different regions Agra, Mathura and Aligarh in West Uttar Pradesh (India) were analyzed.

**Keywords:** Nutritional potential; Zingiberaceae; Curcumin; *Curcuma longa L.*

### 1. INTRODUCTION

The Indian subcontinent is enriched by a variety of flora- both aromatic and medicinal plants. This extensive flora has been greatly utilized as a source of many drugs in the Indian traditional system of medicine. In India, the use of medicinal plants is to be found in Rigveda between 4500-1600 BC [1].

Turmeric (*Curcuma longa L.*) belongs to the Zingiberaceae family. The name derives from the Latin term terra merita, meaning 'meritorious earth', referring to the colour of ground turmeric, which resembles a mineral pigment. In India, it is popularly known as Haldi (Hindi). *Curcuma longa L.* grows naturally in tropical climate and rainy regions of the world such as India, China, Indonesia, Jamaica and Peru [2]. It is a short stemmed perennial, which grows up to 100 cm in height and needs 20 to 30°C temperature. India is the major producer and exporter of turmeric at present, even though the crop is grown in several countries: Pakistan, Malaysia, Myanmar, Vietnam, Thailand, Philippines, Japan, China, Korea, Sri Lanka, the Caribbean Islands and Central America. It is estimated officially that about 80% of the world production of turmeric is from India alone.

The rhizomes of *Curcuma longa L.* have been widely used as a traditional medicine in India, Japan, China, and Southeast Asia as a carminative, stomachic, anthelmintic, laxative and liver ailment therapeutic [3,4]. More than 100 components have been isolated from turmeric. The main component of the root is a volatile oil,

containing turmerone, and there are other coloring agents called curcuminoids in turmeric. Curcuminoids consist of curcumin demethoxycurcumin, and bisdemethoxycurcumin, (Figure 1-3). Curcumin gives turmeric, its characteristic, mild flavor and yellow colour. Curcumin exhibits a variety of biological and photochemical activity, including antitumor, antioxidant, anti-inflammatory, anti-HIV, anti-Alzheimer's, anti-hepatotoxic and cardiovascular protection activities [5-11] leading to increased interest in recent years [12,13].

The nutritional and composition values of any plant vary with the geographic conditions. Since there was no study has been carried out to investigate the minerals contents and nutritional values of *Curcuma longa L.* cultivated in West Uttar Pradesh (India). Hence keeping the above in view the present work was to determine the minerals contents and nutritional values of *Curcuma longa L.* cultivated in three different regions of Uttar Pradesh in India.

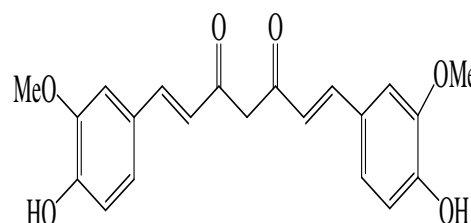
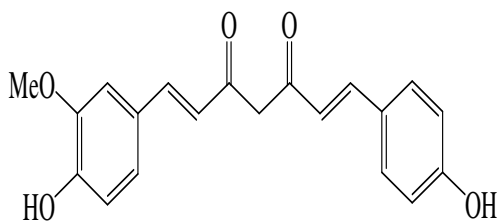
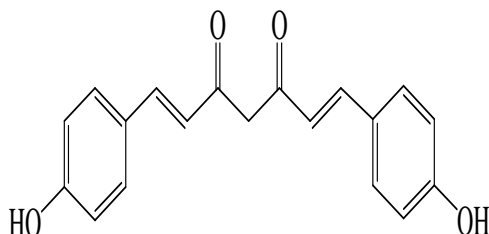


Figure - 1: Curcumin {Compound-1}.



**Figure - 2: Demethoxycurcumin{Compound-2}.**



**Figure - 3: Bis-demethoxycurcumin {Compound-3}.**

## 2. Material and methods

### 2.1. Reagents and Samples

All the solvents were of Analytical Grade and were purchased from Rankem (India).  $\text{HNO}_3$  and  $\text{HClO}_4$  were also purchased from Rankem (India). Rhizomes of *curcuma longa L.* were collected from three different cities of West Uttar Pradesh in India namely, Agra, Mathura and Aligarh. Specimens are preserved in the institute herbarium of K.R. Collage Mathura, Uttar Pradesh, India. The *Curcuma longa L.* rhizomes were thoroughly washed with distilled water and dried in sun for two week and grinded in electric mill for making its power. Moisture content of *curcuma longa* rhizomes was determined according to an air-oven method. Ash content was determined by incinerating at 410-440 °C until the constant weight was achieved. Analytical grade Riboflavin, thiamine and L-ascorbic acid and amino acids standard were purchased from Himedia (India). The stock and standard solution were prepared in mobile phases. For HPLC analysis, millipore water was used throughout the studies.

### 2.2. Instrumentations

Mineral nutrients in *curcuma longa L.* rhizomes were analyzed using a Perkin-Elmer A-Analyst 800 atomic absorption spectrometer by suitable hollow cathode lamp after the digestion of ash of leaves using  $\text{HNO}_3$ ,  $\text{H}_2\text{SO}_4$  and  $\text{HClO}_4$  acid and diluting with double distilled water to a specific volume.  $^1\text{H}$  NMR spectra were recorded on a Bruker DRX-500 spectrometer in  $\text{DMSO-d}_6$ . Vitamins (riboflavin, thiamine and ascorbic acid) and amino acids were analyzed using reverse phase high performance liquid chromatography using waters HPLC system. The HPLC system consists of water 1525 binary HPLC pump and

717 plus auto sampler (waters®). The system was operated at ambient temperature. The chromatographic peaks of amino acids were identified and quantified by Breeze™ software (Version 3.2). Amino acids were analyzed AccQ Tag™ reverse phase (3.9×150 mm) 4 μm analytical column equipped with 2475 multi fluorescence detector (emission and excitation wavelength 395 and 250nm). Cystine and Methionine were analyzed from the same method of acid hydrolysis after treatment using performic acid oxidation while vitamins (riboflavin, thiamine and ascorbic acid) were analyzed using an octadecyl end capped RP-C18 column (4.6 mm i.d. ×25 cm) 5 μm pore size equipped with a UV detector.

### 2.3. Preparation of standard solution

Standard solution of ascorbic acid was prepared by dissolving 50 mg of ascorbic acid in meta-phosphoric acid (0.3 M) and acetic acid (1.4 M) solution (1:4 ratio) at the final concentration 1mg/ml. Standard solution of riboflavin was prepared by dissolving 50 mg riboflavin in double distilled water followed by addition of three to four drops of glacial acetic acid and warming the solution to 85°C. Final concentration of the riboflavin was made to 100 μg/ml where as the standard solution of thiamine was prepared by dissolving 26.7 mg of thiamine hydrochloride in 25 ml of doubly distilled water. The standard solutions of amino acids were prepared in mobile phase.

### 2.4. Chromatographic conditions

Many analytical methods have been reported by various researchers for the determination of thiamine, riboflavin and ascorbic acid [14-16]. Selection of method generally depends upon accuracy, sensitivity and the interferences encountered in the sample matrix. Chosen method of thiamine, riboflavin, and ascorbic acid were identified by comparing the retention time of the sample peak with that of the thiamine, riboflavin, and ascorbic acid standard at 250, 270 and 254 nm. Quantification was carried out using external standard. For the identification of thiamine, riboflavin mobile phase (12.5 mM sodium acetate in a mixture of methanol/ water 25/75 mM sodium heptane sulphonate) with a flow rate of 1.0 ml/min was used while for the identification of ascorbic acid mobile phase (0.1M potassium acetate pH 4.9 in a mixture of acetonitrile water 50/50) with a flow rate of 1.4 ml/min was used.

### 2.5. Sample preparation for analysis of trace elements

Dry ashing method was adopted by placing the properly dried 20.0 g powder of

*curcuma longa L.* sample into the versatile crucible overnight in an electric muffle furnace maintaining the temperature between 400-440 °C. This ashing will destroy all the organic material from the sample. The ash was removed from crucible and dried in desiccators. The yield of ash was approx 6.3g/100g. One gm of ash was taken and digested using conc. HNO<sub>3</sub>, H<sub>2</sub>SO<sub>4</sub> and HClO<sub>4</sub> in the ratio of 10:6:3. Digested ash was stored in sterilized bottles and used for the determination of Ca, Zn, Mg, Fe, Na, and P by flame atomic absorption spectroscopy. Phosphorus was analyzed with colorimeter using ammonium vanadate-molybdate method. Three replicates were prepared for each sample.

## 2.6. Sample preparation for analysis of vitamins

Riboflavin and thiamine were extracted using the method described in literature [17]. One gram of *Curcuma longa L.* rhizomes powder was transferred into a 50 ml graduated polypropylene centrifuge tube and followed by the addition of 20.0 ml of 0.1 H<sub>2</sub>SO<sub>4</sub>. The mixture was shaken vigorously for 1 min, and then placed in boiling water for 30 min and shaken at 5 min intervals. Now the mixture was cooled in an ice bath and followed by the addition of 2.5 ml of 2% α-amylase. After mixing properly, the mixture was incubated at 50°C for 1 hr in a water bath with shaking. The mixture was cooled and then diluted to 25 ml with deionised water. The resulting mixture was centrifuged. The supernatant was filtered through a 0.45 μm nylon filter disc before HPLC analysis. All samples were carried out in triplicate.

Vitamin C was extracted using the modified method of Abdalnabi et al. [18]. One gram of *Curcuma longa L.* rhizomes powder was homogenized with an extracting solution containing meta-phosphoric acid (0.3 M) and acetic acid (1.4 M). The mixture was placed in a conical flask (wrapped with aluminum foil) and agitated at 100 rpm with the aid of an orbital shaker for 15 min at room temperature. Mixture was then filtered through a Whatman filter paper No. 4 to obtain the clear extract. The sample to extraction solution ratio was 1:1. All samples were extracted in triplets.

## 2.7. Sample Preparation for analysis for amino acids

The sample was hydrolyzed in triplet using 6N HCl at 110°C for 24 h and derivatized using AccQ reagent (6'Aminoquinol-N-hydroxysuccinimidyl carbamate) [19].

## 2.8. Extraction of curcuminoids

A 50 g turmeric powder is placed in a timber of Soxhlet extractor. The curcuminoids were extracted using various solvent as reported by S. Revathy et al. [20]. The extraction was carried out for 6 hours to ensure the complete extraction of curcuminoids. The solvent was removed at low pressure until it became semi solid and then this solution was subjected to cooling at 4°C. The orange yellow colored crystals of Curcuminoids were appeared after some time and separated out by filtration. The separated crystals of curcuminoids were dried and weighed.

## 2.9. Separation of curcuminoids

The separation of extracted curcuminoids was carried out using column chromatography technique. Yellow colour crystals (2.5 g) were dissolved in acetone followed by the addition of 20 gm silica gel. This mixture was dried up and loaded onto a 20 cm×2.5 cm silica column packed with benzene. The column was eluted with benzene and ethyl acetate mixture. Three yellow coloured bands were observed. Compound 1 was eluted with benzene/ ethyl acetate (80:20 v/v), whereas compounds 2 and 3 were eluted using benzene/ ethyl acetate (70:30v/v) and benzene/ ethyl acetate (60:40 v/v), respectively. The solvents from elutes were removed at reduced pressure. Thus obtained compounds were recrystallized. Yield: Compound 1 (52 mg), 2 (110 mg), and 3 (80 mg). m.p. compound 1, 187°C, compound 2, 177°C and compound 3, 232 °C. <sup>1</sup>H NMR (DMSO-d<sub>6</sub>): compound 1, 3.90 (6H, s), 5.9 (1H, s), 6.60 (2H, d), 6.83 (2H, d), 7.10 (2H, d), 7.2 (2H, s), 7.55 (2H, d). Compound 2: 3.92 (3H, s), 5.99 (1H, s), 6.68 (2H, d), 6.90 (3H, m), 7.18 (1H, d), 7.34 (1H,s), 7.57 (2H, d), 7.63 (2H, s) compound 3: 5.98 (1H, s), 6.66 (4H, d), 6.90 (3H, d), 7.56 (4H, d), 7.63 (1H, s).

## 3. Result and discussion

### 3.1. Minerals

Atomic absorption spectroscopy has been successfully used for determination for five essential elements i.e iron, zinc, magnesium, calcium and sodium in *Curcuma longa L.* collected from nine different sampling sites of three cities of West Uttar Pradesh. The moisture contain in *Curcuma longa* root is 74.32%.

Results in Table-1 and Figure 4 show the presence of variable amount of metals in these samples. In general, the order of concentration of metals has been found as P> Ca> Mg> Na>Fe>Zn. The concentration of phosphorus was found in the range between 97 mg/100g to 125 mg/100g. The high phosphorus concentration was found at site-I(a), Aligarh while site-II(b), Mathura showed low phosphorus concentration. The balance of

phosphorus and calcium is regulated by parathyroid hormone, which increases urinary excretion of phosphate under conditions of high phosphate and low calcium intake [21]. Recommended dietary allowances have been set at 460–1250 mg of phosphorus per day for different age groups by the United States Institute of Medicine [22]. Calcium uptake in *Curcuma longa* L. was higher *i.e* 168mg/100g at site-III(a), Agra while minimum 138 mg/100g at site-II(c), Mathura. It controls the membrane structure, membrane permeability and provides the stability to cell [23]. Calcium is essential for healthy bones, teeth and blood [24]. The health of the muscles and nerves depends on calcium. The recommended daily allowance of Ca for children is between 500mg and 1000 mg and for adults 800 mg [25]. Magnesium maximum uptake was found at site-III(c), Agra while lower uptake was found at site-II(b), Mathura about 145 mg/100g. Magnesium daily dietary intake ranged from 400 to 420 mg/day [26]. Sodium content in *Curcuma longa* L. rizomes ranged from 28 mg/100g to 35mg/100g. Maximum sodium content was found at site -III(b), Agra and the minimum was noted at site-II(a), Mathura. Sodium as an essential macro element has physiological effect in human and animal cellular and metabolic mechanism. The increased level of sodium content has direct link to the high blood pressure [27]. The daily recommended range of Na in developing countries is between 2400-5175 mg/day [28]. Iron content in *Curcuma longa* L. rizomes ranged from 11 mg/100g to 25mg/100g. Maximum iron content was found at site-I(b) Aligarh and the minimum was noted at site-III(c)Agra. Iron content analyzed in the present study was similar to that reported by Ansari *et al.* [27] in the same rizomes (800µg/g). Iron is one of the essential metal needed in various enzymatic reactions and its daily requirement is ranged from 1.5-2.2 mg/day [29]. Samples of *Curcuma longa* L. collected from site-II(c), Mathura contain comparatively higher amount of zinc (3.5 mg/100g), whereas site-III(c), Agra show low concentration of zinc (2.1 mg/100g) According to the WHO recommendations, fruits and vegetables are poor sources of zinc and ranged upto 1 mg/kg and dietary intake for zinc is 14-20 mg/day [30]. Some workers reported 38.68 ppm zinc in curcumin [31].

### 3.2. Vitamins

The comparative study was conducted to determine the presence of different vitamins *viz.* thiamine, riboflavin and ascorbic acid (vitamin C) in *Curcuma longa* L. rizomes, collected from different sample sites. The concentration of thiamine, riboflavin and ascorbic acid reported in Table-2 and Figure-5. Ascorbic acid content in

*Curcuma longa* L. rizomes of different sites varied from 18.86 mg/100g to 24.32 mg/100g. A significant variation was observed in Ascorbic acid content in *Curcuma longa* L. rizomes. Almost similar values have been reported earlier [32]. Various regions including differences in soil analysis, different environmental conditions and maturity of plant [33]. Ascorbic acid act as antioxidants and potentially act as anticancer agent because Ascorbic acid acts in the stomach as scavenger of nitrites and free radical formed during metabolic processes [34]. The concentration of thiamine (vitamin B<sub>1</sub>) and riboflavin (vitamin B<sub>2</sub>) were found in the range between 0.15 mg/100g to 0.23 mg/100g and 0.17 mg/100g to 0.23 mg/100g at different sampling sites respectively. The relative graphical representation of these vitamins according to their sampling sites is shown in Figure-2. Recommended dietary allowance for riboflavin for adult is 1.3 mg per day for man and 1.1 mg per day for woman [35]. Thiamine intake through supplement is 2.4 mg per day for man and 3.2 mg per day for woman. Approximately 27% of adults took thiamine supplements to recover deficiency of Thiamine [36].

### 3.3. Amino Acids

Amino acid profile of *Curcuma longa* L. root is represented in Table 3 and Figure 6. The protein content in *Curcuma-longa* is 4.8 g/100gm The present method determines the seventeen amino acid namely Leucine, Valine, Lysine, Threonine, Phenylalanine, Isoleucine, Methionine, Histidine, Alanine, Arginine, Aspartic acid, Cystine, Glutamic acid, Glycine, Proline, Serine and Tyrosine. Glutamine and asparagines was expressed as glutamic acid and aspartic acid respectively. In which first eight amino acids are essentials amino acids where as last nine were non essentials amino acids. *Curcuma longa* L. root contained average 53.29, 52.67 and 50.25 mg/100gm total amino acids at site-I (Aligarh), site-II (Mathura) and site-III (Agra) respectively while essential amino acids were found 18.86, 18.46 and 17.40mg/100g of at site-I (Aligarh), site-II (mathura) and site-III (Agra) respectively. On analyses of obtained results it was found that aspartic acid was found highest average values 14.27mg/100g followed by glutamic acid 7.69mg/100g, leucine 6.7mg/100g, tyrosine 3.47mg/100g, valine 3.47mg/100g, serine 2.74mg/100g, alanine 2.74mg/100g and histidine 2.11mg/100g. The average concentration of aspartic acid was found highest at site -III(a), Agra and lowest at site II(a)Mathura. The concentration of glutamic acid was found highest at site-I (b) Aligarh and lowest at site III(c) Agra. Similarly, the concentration of Leucine and tyrosine are found highest value at site-I(a) Aligarh and site-II(a)

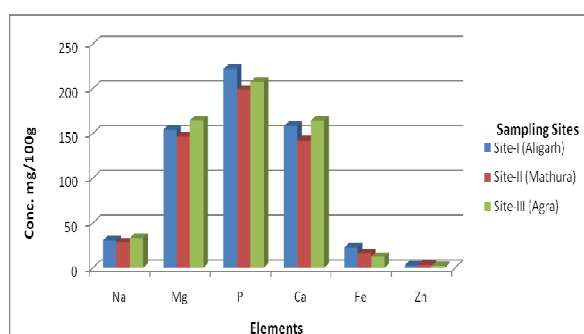
Mathura, while lowest concentration of these amino acids were found at site-III(a) Agra and site I(c) Aligarh respectively.

Methionine, proline and arginine were found lowest concentration among all the amino acids present in *Curcuma longa L.* root. The average values of these amino acids are 0.26mg/100g, 0.71mg/100g and 0.80mg/100g. The concentration of cystine was not detected. Methionine was found lowest at site-

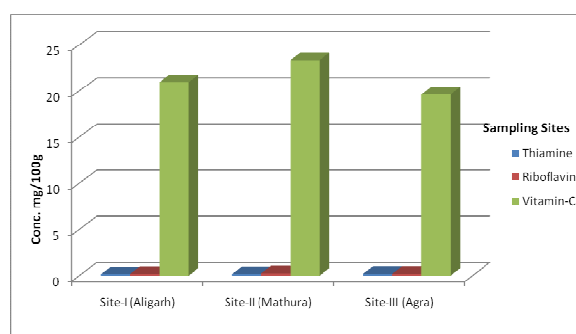
III Agra, and high at site-I Aligarh. Similarly, proline and arginine were found minimum at site-III, Agra and site-II mathura. Whereas the higher values of these amino acids were found at site-I Aligarh. In the investigated material, the dominant amino acid was aspartic acid and glutamic acid. On comparison, it was found that amounts of amino acid present in *Curcuma longa L.* root are close agreement with the literature [37, 38].

**Table - 1: Concentration of trace elements (mg/100g) in leaves of *Curcuma longa L.* at different sampling sites.**

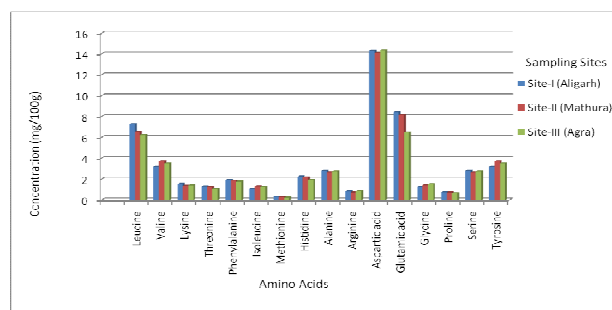
<i>Curcuma longa L.</i> (mg/100g)							Total Ash: 6.3 g/ 100g		
Element	Site-I (Aligarh)			Site-II(Mathura)			Site-III (Agra)		
	a	b	C	a	b	c	a	B	c
Na	32	29	31	28	29	28	33	35	32
Mg	158	151	153	148	145	146	165	167	162
P	125	122	119	98	97	101	109	112	102
Ca	160	158	157	146	143	138	168	161	164
Fe	22	25	21	17	16	15	12	14	11
Zn	2.8	2.6	3.1	3.4	3.1	3.5	2.2	2.5	2.1



**Figure - 4: Trace elements in *Curcuma longa L.* at different sampling sites.**



**Figure - 5: Vitamins in *Curcuma longa L.* at different sampling sites.**



**Figure - 6: Concentration of essential and nonessential amino acid (mg/100g) in *curcuma longa L.* roots at different sampling sites.**

**Table - 2: vitamins composition of *Curcuma longa L.* seeds (mg/100g)**

<i>Curcuma longa L.</i> (mg/100g)									
Vitamins	Site-I (Aligarh)			Site-II(Mathura)			Site-III (Agra)		
	a	b	c	a	b	C	a	b	c
Thiamin	0.15	0.16	0.15	0.16	0.18	0.16	0.23	0.21	0.19
Riboflavin	0.19	0.17	0.17	0.25	0.27	0.23	0.22	0.19	0.19
Ascorbic Acid	22.12	21.23	19.53	23.23	24.32	22.45	19.76	18.86	20.21

**Table - 3: Concentration of essential and nonessential amino acid (mg/100g) in *curcuma longa L.* roots at different sampling sites.**

<i>Curcuma longa L.</i> (mg/100g)									
Essential amino Acids	Site-I (Aligarh)			Site-II(Mathura)			Site-III (Agra)		
	a	b	c	a	b	C	a	b	c
Leucine	7.36	7.31	7.23	6.43	6.36	6.86	6.21	6.27	6.24
Valine	3.21	3.18	3.16	3.76	3.72	3.68	3.52	3.55	3.48
Lysine	1.58	1.52	1.54	1.35	1.38	1.34	1.41	1.43	1.39
Threonine	1.32	1.28	1.29	1.21	1.24	1.32	1.13	1.12	0.99
Phenylalanine	1.94	1.89	1.92	1.87	1.82	1.83	1.76	1.78	1.72
Isoleucine	1.12	1.11	0.98	1.34	1.32	1.29	1.23	1.25	1.26
Methionine	0.32	0.29	0.29	0.27	0.29	0.24	0.21	0.23	0.22
Histidine	2.24	2.21	2.27	2.12	2.18	2.17	1.98	1.92	1.88
Alanine	2.86	2.82	2.78	2.68	2.63	2.65	2.72	2.79	2.75
Arginine	0.84	0.82	0.79	0.74	0.71	0.73	0.87	0.82	0.83
Aspartic acid	14.34	14.23	14.42	13.98	14.21	14.14	14.53	14.34	14.21
Cystine	ND	ND	ND	ND	ND	ND	ND	ND	ND
Glutamic acid	8.32	8.65	8.31	8.12	8.43	7.98	6.48	6.46	6.44
Glycine	1.32	1.21	1.31	1.43	1.46	1.38	1.56	1.48	1.51
Proline	0.78	0.73	0.75	0.71	0.73	0.76	0.68	0.65	0.63
Serine	2.86	2.82	2.78	2.68	2.63	2.65	2.72	2.79	2.75
Tyrosine	3.21	3.18	3.16	3.76	3.72	3.68	3.52	3.55	3.48

#### 4. CONCLUSIONS

The result obtained in this study showed that *Curcuma longa L.* cultivated in three different regions Agra, Mathura and Aligarh are nutritious spice that provide sufficient amount of nutrients and vitamins needed for normal body function, maintenance and reproduction. The concentration of some of the trace metals, vitamins and essential amino acids were differed by the various *Curcuma longa L.* cultivated country. These differences could be explained by local growing conditions such as soil type and water. Turmeric is rich in curcuminoids, consists of a mixture of three curcuminoids, namely, curcumin, demethoxycurcumin, and bisdemethoxycurcumin. Results concluded from the study indicate that the

*Curcuma longa L.* can serve as a good nutritional source in combating malnutrition.

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