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Comparative analysis of nutraceutical potential of turmeric grown in different areas of Almora, Uttarakhand

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Abstract

Curcuma longa (Turmeric) is an important medicinal condiment, which is known for its unique phytochemicals and biological activities. Seven turmeric powder samples obtained from five different locations of Almora District, Uttarakhand were compared for their nutraceutical potential in terms of proximate composition, phytochemical constituents such as phenolics and flavonoids, along with their antioxidant potential, curcumin, minerals etc. The commercial brand was taken for comparison purposes. Total fat was found highest in Jamradi sample (10.07%) while lowest was found in commercial sample (2.72%). The curcumin (5.13%), total phenolic (2.12 mg GAE 100 mg^{-1} DW) and flavonoid contents (5.43 mg QE 100 mg^{-1} DW) were highest in the Tani turmeric sample. DPPH activity of Dharad and Market samples were quite comparable (0.24 mg AAE 100 mg-1 DW), and FRAP activity was highest for Hawalbagh sample (0.44 mg AAE 100 mg-1 DW). Total fat, total moisture, phytic acid and oxalate content were identified as main factors causing difference among the turmeric samples.

Keywords: *Curcuma longa*, antioxidant activity, minerals, curcumin

Introduction

Curcuma longa (Turmeric), known as a golden spice belongs to Zingiberaceae family that gives many Asian dishes their yellow colour and pungent earthy flavor. It is also used as a food preservative. It is widely used in religious ceremonies, ayurvedic and folk medicines against various ailments (Tanvir *et al*. 2017). This herbaceous perennial is cultivated extensively in India, China, and many regions of tropical Southeast Asia. India contributes 80% of the turmeric production in the world and Uttarakhand shares 0.18 % of the total turmeric production in India (National Horticulture Board, India). As per the official website of the State Horticulture Mission, Government of Uttarakhand (2019-2020), turmeric production is 14748.65 MT from an area of 1769 ha area in the state. In Uttarakhand, Almora is the second-largest producer after Pithoragarh with a production of 313 MT from an area of 181 ha.

This spice is rich in proximates and other nutritional components (protein, fat, essential oil, vitamins amino acids, etc.,) and its main popular compound is curcumin which comes under curcuminoids (Serpa Guerra *et al*. 2020). These curcuminoids give yellowish-orange colour to the rhizome and also responsible for its therapeutic activities (Agrawal & Goel 2016; Kumar & Sakhya 2013; Mohebbati *et al*. 2017). The nutritional properties vary with locations where the plant is grown (Hossain & Ishimine 2005; Srinivasan *et al*. 2016). Hence location specific studies are required which will be helpful in promoting the production of turmeric in regions where the nutritional composition and curcumin content are high. The present study is based on the analysis of the nutraceutical potential of turmeric grown in 6 different locations of Almora district of Uttarakhand in terms of their nutritional components, curcumin content, antinutrients and antioxidant potential.

Materials and methods

Chemicals and reagents

Ascorbic acid (AR), quercetin (AR), gallic acid (AR), tannic acid (AR), 1,1-diphenyl-2-picrylhydrazyl (DPPH) (AR), and curcumin were procured from Sigma-Aldrich (Germany) whereas methanol (HPLC), 2,4,6-tripyridyl-1,3,5-triazine (TPTZ) (AR), ferrous chloride (AR), sodium carbonate (AR), hexane (AR), boric acid (AR), sulphuric acid (AR), hydrochloric acid (AR), sodium hydroxide (AR) were procured from Merck Co. (Germany).

Sample collection

Turmeric powder samples were collected from six different locations of Almora District i.e., Hawalbagh from Hawalbagh block, Tani, and Dharadfrom Bhikiyasain block, Nafda, and Pantkotll from Tarikhet block and Jamradi from Bhaisiyachhana block (FS 1), while one commercial brand sample was collected from the local market for comparison purpose. The turmeric samples were kept in airtight well-labeled boxes at room temperature until analyzed.

Extraction procedure

2 g ground turmeric samples were macerated with 30 ml of 85% methanol at ambient conditions using rotary shaker (Remi, India) for 24 h and the process was repeated until the clear extract was obtained. The extracts were filtered through Whatman no. 1 filter paper, and all the extracts were mixed, stored at -20°C in a freezer until further analysis.

Determination of proximate parameters and curcumin content

The nitrogen content in the turmeric samples was determined using an automated Kjeldahl apparatus (Pelican Equipments), through which the total protein content was calculated using multiplication factor 6.25. The ash content, total moisture content, and fat were determined following AOAC, 2016 method (methods 930.15 (4.1.06); 942.05 (4.1.10) and 2003.06 (4.5.06) methods) (George & Latimer 2016). Total carbohydrate content was determined using the Difference Method (Kandyliari *et al*. 2020; Standal 1963) following equation (1)

%Carbohydrate = 100 − (%Moisture+%Crude protein+%Total ash+%Crude fat) (1)

Estimation of total phenolics, flavonoids and curcumin content

Total flavonoid content in the methanolic extracts was determined following modified method (Bao *et al*. 2005; Zhishen *et al*. 1999). 0.5 mL methanolic extracts were diluted to 2 mL using distilled water. Thereafter, 0.15 mL 5% sodium nitrite solution was added and allowed to stand for 5 min. Further, 0.15 mL of 10% aluminum chloride was added in the mixture and was shaken. After 6 minutes, 1 mL 1 M sodium hydroxide solution was added in the mixture, and again shaken. The mixture

was further incubated for 15 min and for the measurement of total flavonoid content, the absorbance of the mixture was read at 510 nm. The calibration curve was prepared using quercetin standard solution (1-10 mgL^{-1}), which was used for the quantification of total flavonoid content in the samples. The results were expressed in mg quercetin equivalent per g dry weight of sample (mg QE 100 mg^{-1} DW).

Total phenolic contents in the methanolic extracts were determined colorimetrically using Folin-Ciocalteu's method (Singleton & Rossi 1965). 0.25 mL methanolic extract was diluted to 2 mL using distilled water and 0.25 mL Folin-Ciocalteu's reagent was added. The mixture was allowed to stand for 5 min, further after neutralizing the mixture using sodium carbonate (7%), the mixture was kept in the dark at ambient conditions for 90 min. The ambience of the blue colour developed in the mixture was measured at 765 nm using a UV–Vis spectrophotometer. The calibration curve was prepared using gallic acid standard solutions (1-10 mgL^{-1}) and was used for the quantification of total phenolic content in the samples. The results were presented in mg gallic acid equivalent per gram dry weight of the sample (mg GAE 100 mg^{-1} DW).

The curcumin content (%) in aqueous methanolic extracts (85%) was determined using a UV-Vis spectrophotometer (Shimadzu) by measuring the absorbance at 428 nm. The standard curve was prepared using curcumin standard ranging from 1-5 mg/L which was prepared using 85% methanol.

Determination of antioxidant activity

DPPH radical scavenging ability assay

DPPH free radical scavenging activity was performed through the modified method, originally given by Blois (Agnihotri *et al*. 2015; Blois 1958). 2.5 mL of methanolic extract was taken in test tubes and mixed with 2.5 mL of 0.3 mM DPPH. The mixing was followed by incubation for 20 min at ambient conditions. The absorbance of the mixture was measured at 517 nm. Result was expressed as mg ascorbic acid equivalent per 100 mg dry weight of the sample (mg AAE 100 mg^{-1} DW) based on standard curve, prepared using ascorbic acid dissolved in 85% methanol with the concentration ranging from 1-10 mg L^{-1}.

FRAP antioxidant assay

Ferric reducing antioxidant power (FRAP) of the methanolic extract of turmeric samples was measured following the method given by Benzie and Strain (Benzie & Strain 1996) with slight modifications. For the preparation of FRAP reagent, 10 volumes of 0.3 M acetate buffer, 1 volume of 20 mM ferric chloride, and 1 volume of 10 mM TPTZ in 40 mM HCl were mixed. The 3.6 mL of FRAP reagent was added to 1.0 mL methanolic extract and incubated at 37°C for 10 min followed by measurement of absorbance at 593 nm. FRAP was analyzed in terms of mg ascorbic acid equivalent per 100 mg dry weight of the sample (mg AAE 100mg^{-1} DW) based on the calibration curve, prepared with ascorbic acid dissolved in 85% methanol with the concentration ranging from 1-25 mg L^{-1}.

Determination of minerals and antinutrient content

Mineral estimation in all the turmeric samples were carried out after digesting the samples using Allen's method (Allen 1989). Sodium and potassium were analyzed using flame photometer (Systronic flame photometer 128), and phosphorus and iron were determined colorimetrically using UV–Vis spectrophotometer (George & Latimer 2016; Murphy & Riley 1962). Antinutrients such as tannins, phytic acid, and oxalate content were determined using standard methods (Abaza *et al*. 1968; Price *et al*. 1978; Sadasivam & Manickam 1996; Wheeler & Ferrel 1971). The quantification of tannin content was done based on the calibration curve of catechin standard solution (500-1000 mg L^{-1}), prepared in 85% methanol, and was expressed as mg catechin

equivalent per 100 mg dry weight of the sample (mg CE 100 mg^{-1} DW). The phytic acid was quantified using ferric nitrate as standard (500-1000 mg L^{-1}) and the analysis was carried out at 480 nm. The results were presented in terms of phytate P mg 100 mg^{-1} DW of the sample. The oxalate was analyzed using the titrimetric method. As iron is an important mineral for the human body, and phytic acid affects its availability, so for ensuring their availability while consuming turmeric, the molar ratio of phytate to iron (Phy: Fe) was calculated using Equation (2):

$$\textit{Molar ratio} = \frac{\textit{(Moles of phytate)}}{\textit{(Moles of iron)}} \quad (2)$$

Statistical analysis

All results in this study are reported as means of three replicate analyses. Statistical analysis of the data was done using MS Excel and SPSS 16.0. One-way analysis of variance (ANOVA) was carried out to compare the mean values of proximate nutrients, polyphenolic compounds, antioxidant potential, antinutritional factors, and mineral content among different turmeric samples using SPSS 16.0 at $p \leq 0.05$. For understanding the factors responsible for the variability, turmeric samples were analyzed through factor and cluster analysis (FA and CA) using SPSS 16. Log transformation and z-score were calculated for minimizing the effect of different variables and then the factor scores were obtained using Varimax rotation method with Kaiser's normalization. A scree plot was used to identify the numbers of factors based on eigen values (>1). For cluster analysis, Ward's method was used for linkage study and Euclidian distances as a measure of similarity. The proximity among the turmeric samples is presented in the form of dendrogram.

Results and discussion

Proximate parameters and mineral content

The proximate content of different turmeric samples are shown in Table 1. The proximate composition data of turmeric was compared with that of recommended values of USDA. The highest moisture content was found in the turmeric of Jamradi village (17.36%), whereas the lowest was found in the commercial sample (11.19%). The lower the moisture content, the longer will be the shelf life of turmeric as bacterial and mold growth is inhibited due to lower moisture availability (Bourdoux *et al*. 2016). Ash content represents the presence of mineral constituents in the samples, and it varied in the turmeric samples collected from different areas. The highest ash content was observed in the samples collected from Dharad region (14.07%), while lowest was in commercial sample (6.93%). The value of ash content was higher than the USDA recommended value except commercial sample and the sample collected from Tani area. Total carbohydrate content varied from 77.37% for commercial sample to 60.62% in the sample collected from Jamradi area, which is close to the values recommended by USDA i.e. 67.1%. Among all the samples, protein content was highest in Nafda sample (2.24%) while the lowest was recorded in Pantkotll (0.67%), but it was much less than the USDA recommended value (9.68%). The variation in the amount of protein content might be due to the geographical distribution or soil fertility status (presence of low nitrogen-containing soils) (Baltensperger *et al*. 2008). Total fat was found highest in Jamradi (10.07%) while lowest was in commercial sample (2.72%). The USDA recommended value for total fat is 3.25%. The results of collected samples are quite comparable as reported by Chempakam & Parthasarathy (2008), where the reported standard value of fat, carbohydrates and moisture content for turmeric were 5.1%, 69.4% and 13.1% respectively.

Sodium, potassium, phosphorus, nitrogen and iron contents were analyzed in turmeric samples (Table 2). Among all the analyzed minerals, potassium is the most abundant ranging from

Table 1. Proximate composition (%) in different turmeric samples

Sample	Protein (%)±SE	Carbohydrate (%)±SE	Total fat (%)±SE	Moisture (%)±SE	Ash (%)±SE	Curcumin content (%)±SE
HB	1.89±0.16^{a,b}	71.78±0.39^{b}	5.28±0.101^{e}	12.12±0.47^{b,c}	8.92±0.03^{b,c}	4.35±0.05^{b}
NF	2.24±0.06^{a}	67.55±0.28^{c}	7.11±0.04^{c}	14.94±0.22^{c,d}	8.14±0.04^{c,d}	4.31±0.02^{b}
TA	1.72±0.04^{a,b}	65.31±0.30^{d}	9.52±0.08^{b}	16.47±0.26^{d,e}	6.96±0.16^{d,e}	5.13±0.11^{a}
PT	0.67±0.04^{c}	68.99±0.22^{c}	6.24±0.13^{d}	14.77±0.15^{b,c}	9.32±0.24^{b,c}	2.70±0.01^{d}
JM	1.99±0.22^{a,b}	60.62±0.19^{e}	10.07±0.089^{a}	17.36±0.25^{a}	9.95±0.16^{b}	4.31±0.03^{b}
DH	1.57±0.04^{b}	59.58±0.56^{e}	9.92±0.028^{a}	14.84±0.12^{b}	14.07±0.49^{a}	3.31±0.05^{c}
MT	1.78±0.01^{a,b}	77.37±0.17^{a}	2.72±0.06^{f}	11.19±0.13^{e}	6.93±0.24^{e}	3.22±0.01^{c}

Hawalbagh (HB), Nafda (NF), Tani (TA), Pantkotll (PT), Jamradi (JM), Dharad (DH), Market (MT). Means with different alphabets within the same column indicate significant difference between samples on Post Hoc tukey test (P≤0.05).

1140.55 (mg 100 g^{-1}) in Tani sample to 1482.77 (mg 100 g^{-1}) in Dharad sample. Sodium content was found to vary between 18.72 (mg 100 g^{-1}) for Hawalbagh sample to 61.11 (mg 100 g^{-1}) for Pantkotll sample. Iron content varied between 37.47 (mg 100 g^{-1}) for Nafda sample to 86.8 (mg 100 g^{-1}) for Hawalbagh sample. Phosphorus content ranged from 258.48 (mg 100 g^{-1}) for Pantkotll sample to 447.37 (mg 100 g^{-1}) for Hawalbagh sample. The mineral content in the plant produce depending upon the soil where it is grown. Varying content of N, P, K and Fe in turmeric samples were reported by various researchers (Balakrishnan 2007, Bamigboye *et al*. 2020, Ahamefula *et al*. 2014, Taoheed *et al*. 2017)

Table 2. Mineral content (mg 100 g^{-1}) in different turmeric samples

Sample	Na (mg 100 g^{-1}) ± SE	K (mg 100 g^{-1}) ± SE	Fe (mg 100 g^{-1}) ± SE	P (mg 100 g^{-1}) ± SE
HB	18.72±1.25^{c}	1363.889±10.09^{b}	86.8±2.00^{a}	447.37±6.70^{a}
NF	57.44±2.31^{a}	1281.722±15.39^{b,c}	37.47±1.76^{c}	320.6±3.47^{b}
TA	19.83±0.34^{c}	1140.556±12.01^{d}	41.47±2.90^{b,c}	287.27±8.02^{d,e}
PT	61.11±2.96^{a}	1252.222±19.10^{c}	56.8±1.15^{b}	258.48±4.44^{f}
JM	36±9.43^{b,c}	1249.556±10.36^{c}	48.8±2.31^{b,c}	261.01±7.95^{e,f}
DH	43.90±2.13^{a,b}	1482.778±10.21^{a}	42.8±5.78^{b,c}	318.83±2.16^{b,c}
MT	35.166±0.57^{b,c}	1123.944±9.71^{d}	44.8±6.93^{b,c}	291.06±4.93^{c,d}

Hawalbagh (HB), Nafda (NF), Tani (TA), Pantkotll (PT), Jamradi (JM), Dharad (DH), Market (MT). Sodium (Na), potassium (K), iron (Fe), phosphorus (P). Means with different alphabets within the same column indicate significant difference between samples on Post Hoc tukey test (P≤0.05).

Total flavonoid, phenolic, curcumin, and antinutrient contents

Flavonoids are considered as plant pigments which are responsible for the colour of plants and help in their health-promoting activities through their high pharmacological potential as radical scavengers (Cook & Samman 1996). In our study, total flavonoid content was reported to be highest in methanolic extract of Tani sample i.e. 5.43 mg QE 100 mg^{-1} DW and lowest in methanolic extract of Hawalbagh sample i.e. 3.315 mg QE 100 mg^{-1} DW (Figure 1). These results fall in the similar range as reported (Sumazian *et al*. (2010) and Tilak *et al*. (2004). Plant based phenolics are important constituents that contribute to color, functional quality, flavor and play important roles both as singlet oxygen quenchers and free radical scavengers, that helps to minimize molecular damage (Tanvir *et al*. 2015). In our study, total phenolic content was reported to be highest in Tani sample (2.12 mg GAE 100 mg^{-1} DW) and lowest in Hawalbagh sample 1.35 mg GAE 100 mg^{-1} DW (Figure 1).Curcumin is an exceptionally important polyphenol which has anti-inflammatory and anti-cancer characteristics and has been utilized in several medical preparations for ages. Among the turmeric samples curcumin content was highest in Tani sample (5.13%) and lowest in the Pantkotll (2.70%). Such variation might be due to the genetic variability of turmeric cultivars, from which final turmeric powder was prepared (Anandaraj *et al*. 2014). Similar results was observed in the turmeric cultivars grown in Himachal Pradesh which was ranging from 3.61-5.19% (Choudhary & Rahi 2018).

The antinutrients such as phytic acid, tannic acid and oxalic acid were analyzed in the turmeric samples. Tannic acid was found to vary from 17.58% in Dharad sample to 21.30% in Tani sample, whereas phytic acid was found in the

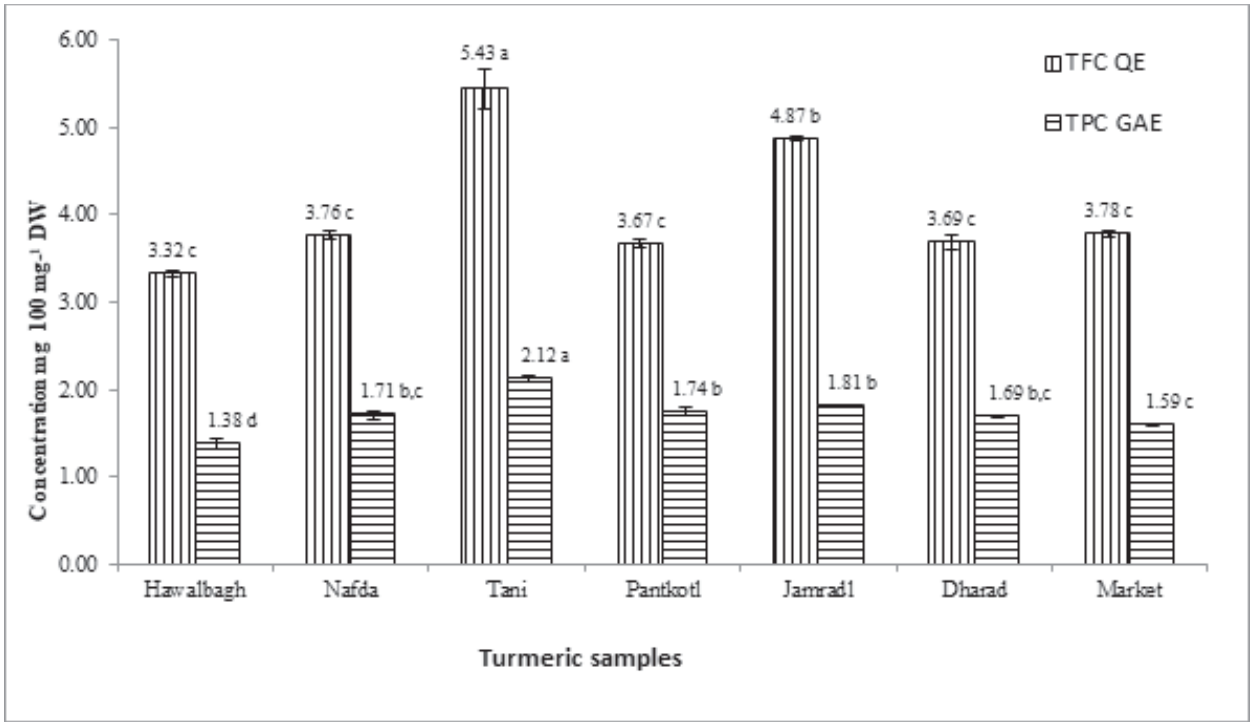

Fig. 1 Total flavonoid and phenolic content in the turmeric samples

Data points marked above the bar are the concentration of total phenolic content (mg GAE 100 mg^{-1} DW) and total flavanoid content (mg quercitine 100 mg^{-1} DW). Values with different alphabets within the same column indicate significant difference between samples on Post Hoc tukey test ($P \leq 0.05$)

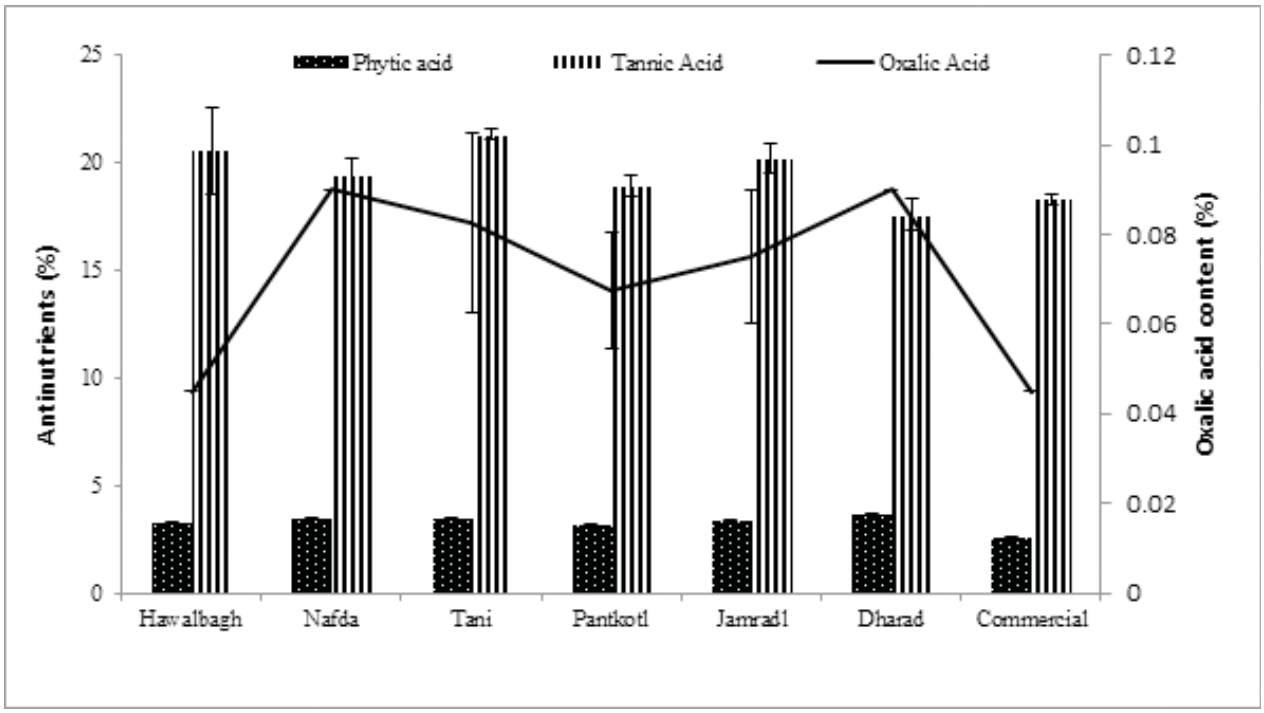

Fig. 2 Antinutrients content in the turmeric samples

range of 2.60% in commercial sample to 3.66%. in Dharad sample and oxalate from 0.045% in commercial sample to 0.90% in Nafda sample (Figure 2). Plants can accumulate significant concentrations of antinutritional components, which can interfere in the digestibility and bioavailability of nutrients in the human body (Braga *et al*. 2018). Phytate plays an important role in lowering the bioavailability of multivalent cations such as Ca^{2+}, Mg^{2+}, Zn^{2+}, Fe^{2+}, and Fe^{3+} by establishing insoluble metal complexes and rendering them unavailable to humans and animals (Reddy & Salunkhe 1980). However, phytate : iron ratio of >1 as observed in the present study indicate that the iron present in the turmeric will be absorbed in the body without getting affected by the presence of phytic acid (Agnihotri *et al*. 2020; Hallberg *et al*.1989).

Antioxidant activity

Turmeric has significant 1,1-diphenyl-2 -picrylhydrazyl (DPPH), superoxide anion radical scavenging, and metal-chelating, ferric reducing/antioxidant power (FRAP) activity (Zhao *et al*. 2010) due to the presence of natural phenolic compounds such as curcuminoids. Among the samples, DPPH activity of Dharad and Market samples was quite comparable (0.24 mg AAE 100 mg^{-1} DW), while the lowest activity was found in the Tani sample (0.112 mg AAE 100 mg^{-1} DW) (Figure 3). The FRAP activity was the lowest for Jamradi sample

Table 3. Phytic acid and iron ratio in different turmeric samples

Sample	PA/Iron ± SE
HB	3.20±0.07
NF	7.84±0.33
TA	7.12±0.48
PT	4.70±0.11
JM	5.86±0.29
DH	7.51±1.00
MT	5.19±0.93

Hawalbagh (HB), Nafda (NF), Tani (TA), Pantkotll (PT), Jamradl (JM), Dharad (DH), Market (MT)

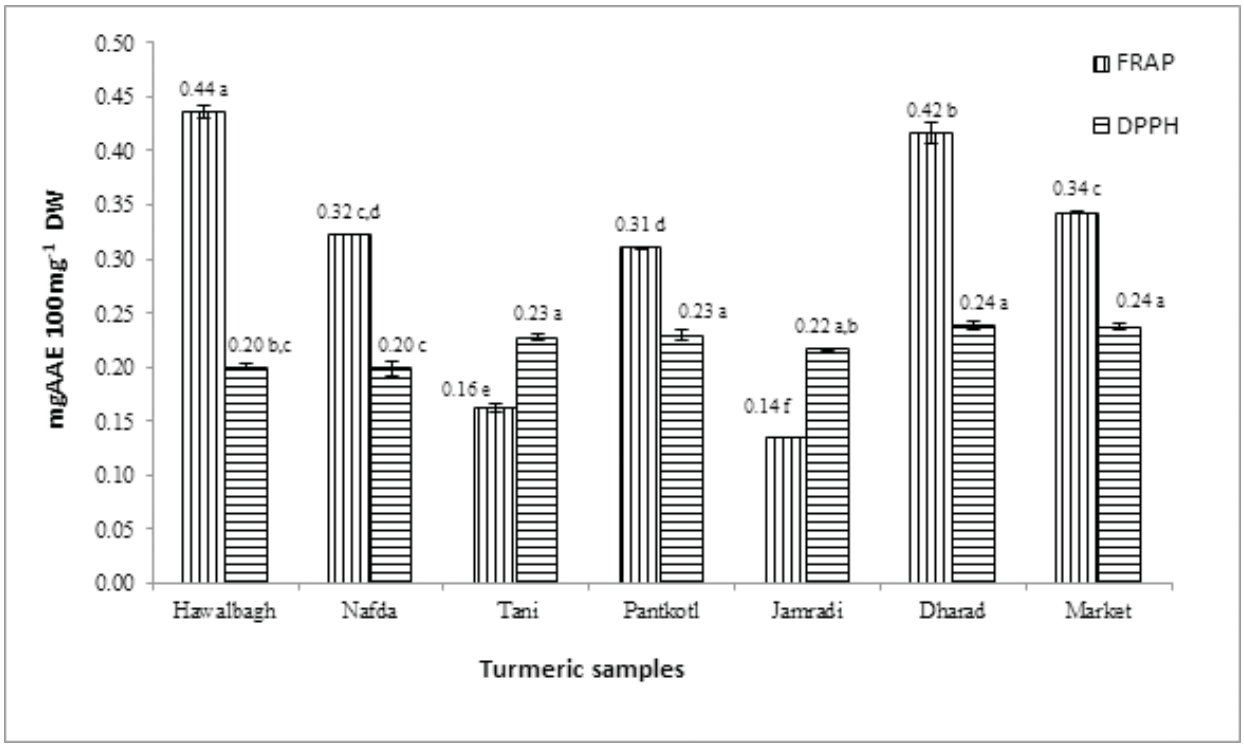

Fig. 3 Antioxidant activity of the turmeric samples in terms of FRAP and DPPH.

Data points marked above the bar are the concentration (mg AAE 100 mg^{-1} DW) for DPPH and FRAP. Values with different alphabets within the same column indicate significant difference between samples on Post Hoc tukey test ($P \leq 0.05$)

(0.14 mg AAE 100 mg^{-1} DW) while the highest activity was recorded in Hawalbagh sample (0.44 mg AAE 100 mg^{-1} DW). Correlation analysis was conducted between total phenolic and flavonoid contents and antioxidant activity and it was observed that phenolic and flavonoid content are not linearly correlated ($p \leq 0.05$). It ispossible that there might be some other bioactive compounds which might be responsible for the antioxidant activity of these samples. The similar conclusion was also drawn earlier by Supawadee Burapan *et al*. (2020).

Multivariate analysis

For analyzing the differences among the selected turmeric samples, factor and cluster analysis were conducted and the results are shown in Table 4 and Figure 4. Four factors were obtained with the total variance of 79.38% among all the analyzed parameters for the targeted turmeric samples. The factor 1 was responsible for 33.54% of total variance and showed high positive loading (>0.70) for total fat, total moisture, phytic acid and oxalate which shows that these parameters are strongly affecting the variation among the targeted turmeric samples and negative loading for total carbohydrates. Factor 2 is accounting for 18.96% of total variance with positive loading for FRAP activity, iron and phosphorus whereas negative loading for total phenolic content. This depicts that total phenolic content is not responsible for FRAP activity. Factor 3 accounts for 19.25% of total variance with positive loading for total flavonoids, curcumin content, and antinutrient tannic acid. Factor 4 accounts for 7.63% of total variance with the positive loading for total protein. The analysis shows that total fat, phytic acid and oxalic acid are the main variables which are the cause of variation among the turmeric samples.

Table 4. Factor analysis for analyzing the parameters responsible for the variation of nutraceutical potential of turmeric samples

Parameter	PC1	PC2	PC3	PC4
Total protein	0.045	0.166	-0.01	0.955
Total carbohydrate	-0.951	-0.045	0.129	0.019
Total Fat	0.967	0.238	-0.083	-0.035
Total Moisture	0.804	0.412	-0.356	-0.186
Total ash	0.692	-0.57	0.236	-0.163
Total Phenolic content	0.445	0.035	-0.765	-0.157
Total flavonoid content	0.456	0.855	-0.001	0.137
DPPH	-0.547	-0.631	0.047	0.477
FRAP	0.204	-0.03	0.917	-0.004
Curcumin	0.001	0.854	-0.314	-0.109
Tannic acid	0.09	0.884	0.275	0.149
Phytic acid	0.958	0.026	0.085	0.135
Oxalic acid	0.815	-0.012	-0.556	0.019
Sodium	0.121	-0.616	-0.566	-0.388
Potassium	0.62	-0.63	0.46	0.081
Iron	-0.192	0.04	0.941	-0.226
Phosphorus	-0.067	-0.212	0.755	0.535
Eigen value	6.426	3.97	3.718	1.58
Total variance (%)	33.54	18.96	19.25	7.63
Cumulative variance (%)	33.54	52.50	71.75	79.38

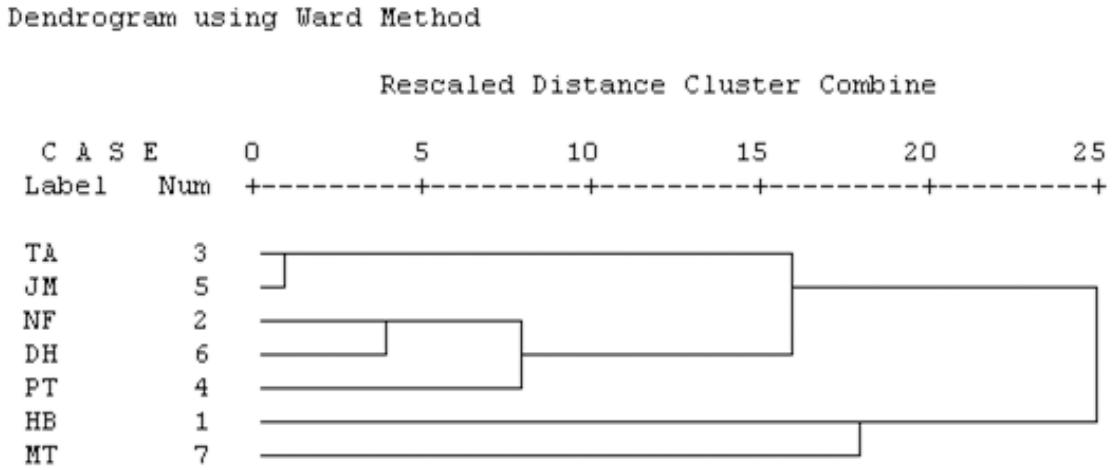

Fig. 4 Clustering of turmeric samples based on the targeted parameters

Through cluster analysis, it was observed that all the targeted turmeric samples could be categorized into two main clusters (Figure 4). In the cluster 1 (C1), Hawalbagh sample and market sample were clustered while rest of the samples were grouped another cluster (C2). Similarity between Hawalbagh sample and market sample is well justified as reviewed by chemical characteristics of both the samples. C2 is further grouped into two sub-clusters, where the turmeric samples of Tani and Jamradi region were grouped in separate sub-cluster (SC1), whereas turmeric samples of Nafda, Dharad and Pantkotll region were grouped in another sub-cluster (SC2). In SC2, Nafda and Dharad samples are in proximity. The differences in nutritional parameters and the respective clustering might be due to the variability in the climatic and soil conditions. Arya *et al*. (2019) reported the soil characteristics of different block of Almora districts show that the soil of areas where turmeric were cultivated was loamy sand to silty clay loam/ sandy loam to silty clay loam and the micro and macro nutrient contents were also varying in these areas (Arya *et al*. 2019). Hawalbagh block was low in nitrogen (N), sulfur (S) and boron (B), medium in copper (Cu), and high in rest of the other nutrients, Tarikhet block was low in N, medium in B and high in rest. Bhikiyasain block was low in N, medium in Fe and B, high in rest. Bhaisiyachhana block was low in N, medium in B and high in rest nutrients. This variation in soil nutrient conditions might be responsible for the variability of nutritional contents along with the genetic variability.

Conclusion

The turmeric is used both as spices as well as in different types of phytomedicines due to its several health benefits. As the turmeric is valued mainly for its curcumin along with many other phytochemicals and minerals, in terms of curcumin, turmeric sample from Tani (TA) village was found best followed by Hawalbagh (HB), Nafda (NF), Jamradl (JM). Total phenolic and flavonoids content were also highest in Tani turmeric sample. Turmeric is also important for its antioxidant activity which was found highest for Hawalbagh turmeric sample followed by that of Dharad in terms of FRAP and in terms of DPPH activity, it was highest and equivalent in the turmeric samples fromTani (TA), Jamradi (JM), Dharad(DH), Market (MT).

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