Exploring the biochemical and antioxidant potential of ginger (Adric) and turmeric (Haldi)

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ABSTRACT

The aim of this present study was to explore antioxidant and bioactive profile of ginger and turmeric. For the purpose, turmeric and ginger (Haldi and Adric) were procured from University of Agriculture, Faisalabad, Punjab-Pakistan. The study was comprised of different phases. Both of the spices were characterized for their chemical composition and mineral profile. Bioactive compound was extracted by using solvent followed by quantification through the high-pressure liquid chromatography. Furthermore, antioxidant potential including total phenolics content, free radical scavenging activity (DPPH assay) and Ferric reducing antioxidant power test (FRAP assay) was analyzed. Results revealed that the antioxidant profile including free radical scavenging activity (47.67 ± 0.19 mg/100 g) and DPPH (80.16 ± 0.23%) of turmeric ginger powder extract was much higher than turmeric and ginger powder extract. Similarly, total phenolics content (103.39 ± 0.58 mg of GAE/g) and flavonoids (4.27 ± 0.05 mg CE/100 g) were much higher in turmeric ginger powder as compared to turmeric powder and ginger powder, respectively. Conclusively, turmeric ginger powder showed higher antioxidant potential.

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Introduction

Beyond the basic function of providing nutrients, functional foods and nutraceuticals are the fundamental rudiments of diet-based therapy due to their health improving potential. Among the health-conscious consumers, the use of such foods is emerging which captured a significant share of the world market nutrition. During the last few decades, a group of scientific tests have proven the value of various biologically active foods which are helpful against life-threatening diseases like obesity, cancer insurgence, hypercholesterolemia and hyperglycemia. Plants based functional foods, among the diet-based interventional strategies, are not only rich in phytochemicals but also enhance wellness and reduce health risk factors.

In the prevention of metabolic syndrome various phyto-remedies including ginger, turmeric, onion, and garlic, etc., have achieved forefront position. The consumption of traditional plants is gradually increasing because of their effectiveness against several physiological threats. As culinary preparation, flavoring and seasoning, ginger and turmeric are vital spices being commonly consumed and play a key role in the disease prevention especially arthritis. Rheumatoid arthritis is degenerative joint disease that occurs when all the bones rub against each other and the cartilaginous cushion lining is deteriorated at the end of the joint. Whereas painful rubbing occurs because of the
osteoarthritis cartilage which is connective tissue in bone joints. Ginger is a well-known herb to contain several bioactive compounds, anti-inflammatory, carminative, antiseptic properties and antioxidants that possesses health-promoting properties.

Turmeric is used for color and flavor, in mustard blends, pickles, and sauces. Turmeric combines the medicinal characteristics of herbs with foods and has been used in Ayurvedic medicine for centuries. [6] Turmeric is very helpful for reducing arsenic toxicity, oxidative damage and genotoxicity induced by lead acetate in animal study. Turmeric is very beneficial in many aspects due to the ingredients like polyphenols, sterols, triterpenoids, diterpenes, sesquiterpenes, and alkaloids which are biologically active. Due to their null toxicity, turmeric and ginger spices have made themselves in good health in comparison to other medications. [7] Turmeric efficacy is well known due to its active component curcumin which affects several signaling pathways and transcription factors. Antioxidant activities of turmeric are exhibited by numerous functional groups possessed by turmeric. Turmeric and ginger dried rhizomes are rich in phenolic curcuminoids that are curcumin, demethoxycurcumin, and bisdemethoxycurcumin as well as pungent phenolic compounds like gingerol and shogaol. [8] Considering the prevalence of arthritis in the Pakistani community and the claimed health benefits of ginger and turmeric, the current study includes characterization of turmeric and ginger with special reference to their antioxidant potential. It includes proximate analysis, mineral profile, and antioxidant profile of both spices.

Materials and methods

Procurement of raw material

The turmeric and ginger (Haldi and Adric) were obtained from the university of Agriculture Faisalabad. The preferred materials were cleaned to get rid from the dirt and other foreign particles, the cloves of turmeric ginger were peeled subsequently, for the preparation of ginger and turmeric extract and powders, similarly, all chemicals and standards were purchased from Merck (Germany) and Sigma–Aldrich (Tokyo, Japan).

Proximate composition and mineral profile

Proximate analysis of turmeric and ginger was carried out for moisture content, crude protein, crude fat, crude fiber, ash, and nitrogen-free extract (NFE) according to the standard methods as described in AACC. [9] Mineral concentration and quantification were done by subjecting the diluted wet digested samples through Atomic Absorption Spectrophotometer (Varian, AA-240, Victoria, Australia). Calcium (Ca), and iron (Fe) were determined by Atomic Absorption Spectrophotometer (Varian AA240, Australia) while potassium (K), sodium (Na), and phosphorus (P) were assessed by Flame Photometer-410 (Sherwood Scientific Ltd., Cambridge). The operating conditions for Manganese determination were wave length 285.5 nm, slit width 1.3 nm, Lamp Current 7.5 nm, Burnner Head standard type, Flame air – Acetylene, Burnner height 7.5 nm, oxidant gas pressure flow rate 160 Kpa, fuel gas pressure flow rate 7 Kpa. [9]

Preparation of extract of turmeric and ginger powder

Ginger and turmeric extracts were prepared using 50% ethanol and water at 60°C for 60 min (Table 1). After that, the solvents were removed through Rotary Evaporator (Eyela N-N, Tokyo, Japan). Gingerol and Curcuminoids rich fraction from turmeric and ginger using different solvent, namely, ethanol and water at different time intervals (30, 60, and 90) and stable temperature at 50°C (Table 1). Both rhizomes were cleaned and washed with deionized water and dried in hot air oven for 5 to 6 h and cut in the small pieces and then crushed in powder form with the help of electronic mill. 70 g of powder was taken into a thimble and put in a Soxhlet apparatus, and dissolved in different solvents for seven hours.
Analysis of ginger and turmeric extract

The ginger and turmeric extracts were used for the determination of their phytochemicals and antioxidant potential. To evaluate the anti-oxidative perspective, total phenols (TPC), DPPH radical scavenging activity (1, 1-diphenyl-2-picrylhydrazyl) and FRAP (Ferric reducing antioxidant power) tests were performed.

Anti-oxidative and phytochemicals profiling of ginger and turmeric

Antioxidant potential and Phytochemical profiling of ginger and turmeric were evaluated through the recommended procedures.

Determination of total phenolics content (TPC)

Total phenolics were estimated through Folin–Ciocalteu method followed by. Accordingly, 50 µL each of ginger and turmeric extract was added to 250 µL of Folin–Ciocalteu together with 750 µL of 20% Na2SO3 solution and volume were made up to 5 mL with distilled water. Absorbance was noted after 2 hours at 755 nm on UV/Visible Spectrophotometer (121–0032, Hitachi instruments Inc. Tokyo, Japan) and the results were expressed as Gallic acid equivalent (mg Gallic acid/g) per dry matter.

Estimation of flavonoids

Flavonoids were determined by the method followed by Ordonez, Gomez, and Vattuone. For this purpose, 0.5 mL of 2% aluminum chloride (ethanolic) was mixed with 0.5 ml turmeric and ginger extract. At room temperature, absorbance was measured after 1 hr at 420 nm. The extracts were evaluated at a concentration of 1 mg/mL and total Flavonoids were calculated as Quercetin equivalent (mg/g).

Free radical scavenging activity (DPPH assay)

The DPPH of turmeric and ginger was measured by the method of Müller, Fröhlich, and Böhm. For this purpose, DPPH (1 mL) was mixed with extract (4 mL) and the mixture was incubated at ambient temperature for half an hour. Afterward, the absorbance was observed at 520 nm by using UV Visible Spectrophotometer.

Ferric reducing antioxidant power (FRAP)

FRAP test was performed as the protocol adopted by the Yuan, Vele, and Lenhoff. In a water bath, for 20 min, sample (0.5 mL) was mixed with the phosphate buffer solution (1.25 mL) and potassium ferricyanide and incubated at 500 C. After that sample was cooled and mixed with 1.25 mL each of TCA & distilled water and 0.25 mL of ferric chloride for 10 min and absorbance was observed at 700 nm.

Table 1. Treatments used for solvent extraction.

| Treatments | Solvent extracts | Time |
|------------|------------------|------|
| T1         | Water            | 30   |
| T2         | Ethanol          | 30   |
| T3         | Water            | 60   |
| T4         | Ethanol          | 60   |
| T5         | Water            | 90   |
| T6         | Ethanol          | 90   |

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Statistical analysis
The data were obtained by applying completely randomized design (CRD) and further subjected to statistical analysis using Statistical Package (Microsoft Excel 2016 and Statistix 9.1). Level of significance was determined (ANOVA, LSD for comparison) using two-factor factorial CRD where applicable following the principles outlined by Steel et al. [14].

Results and discussions
The characterization of raw material is an essential step to determine its quality and nutritional value. Current study was intended to investigate the importance of locally grown spices, the study comprised of two phases, in the first phase ginger and turmeric powder were prepared for the dietary analysis and mineral composition. Secondly, extraction of bioactive compounds from ginger and turmeric was done at different time intervals to evaluate the antioxidant activity of ginger and turmeric. After that, data were collected for the statistical analysis to check the level of significance. The consequences with argument of study attributes are discussed herein.

Compositional profiling
The nutritional composition of ginger and turmeric was determined by proximate analysis. This work was carried out to evaluate the potential of the rhizome of ginger (Zingiber officinale) and turmeric (curcuma longa) for its nutritional and therapeutic utility. In the current investigation moisture, crude protein, crude fat, crude fiber, carbohydrate, ash, and nitrogen-free extract content were determined in ginger at level of 30.21 ± 0.25%, 0.56 ± 0.055%, 5.01 ± 0.48%, 10.9 ± 0.05%, 84.24 ± 0.85%, 5.033 ± 0.10%, 7.23 ± 0.27% whereas in turmeric the values were found to be 11.19 ± 0.28%, 8.72 ± 0.41%, 6.99 ± 0.01, 5.08 ± 0.14, 69.01 ± 0.32, 2.90 ± 0.11, and 70.98 ± 0.43, respectively (Table 2). The nutritional composition of turmeric and ginger varies depending on their harvesting and growing condition. The results obtained for compositional analyzes are comparable with Osabor, Bassey, and Umoh, [15] Tanweer, Shahzad, and Ahmed [16] who found similar results for moisture, protein, fats, carbohydrates, ash, and fiber in turmeric.

Mineral profile
In the current study, mineral, calcium iron, potassium, phosphorus, magnesium, manganese, and zinc were present in appreciable amounts ginger 68.28 ± 0.75 mg/100 g, 8.42 ± 0.50 mg/100 g, 128.58 ± 0.52 mg/100 g, 5.18 ± 0.26 mg/100 g, 102.67 ± 0.69 mg/100 g, 2.15 ± 0.10 mg/100 g, 5.18 ± 0.35 mg/100 g, respectively (Table 3) likewise turmeric was found to have 14.07 ± 0.35 mg/, 19.09 ± 0.33 mg/100 g, 116.6 ± 0.90 mg/100 g, 7.08 ± 0.26 mg/100 g, 93.9 ± 0.65 mg/100 g, 2.70 ± 0.16 mg/100 g, 1.13 ± 0.11 mg/100 g, respectively. The results are consistent with the previous findings of Ereifej et al. [17] who reported the amounts of Ca, zinc, magnesium, manganese was in the range of 0.49 ± 1.9 mg/100 g, 12.23 ± 0.16 mg/100 g, 1.2 ± 1.43 mg/100 g, 7.33 ± 0.22 mg/100 g, respectively. However, finding of Tanweer et al. [16] showed some variations with the current study regarding potassium and phosphorus.

Table 2. Proximate composition.

| Parameters (%) | Ginger       | Turmeric     |
|----------------|--------------|--------------|
| Moisture       | 30.21 ± 0.25a| 11.19 ± 0.28b|
| Crude protein  | 0.56 ± 0.055b| 8.72 ± 0.41a |
| Crude fat      | 5.01 ± 0.48b | 6.99 ± 0.01a |
| Crude fiber    | 10.98 ± 0.05a| 5.08 ± 0.14b |
| CHO            | 84.24 ± 0.85a| 69.01 ± 0.32b|
| Ash            | 5.033 ± 0.10a| 2.90 ± 0.11b |
| NFE            | 7.23 ± 0.27b | 7.98 ± 0.43a |
410.91 ± 91 mg/100 g, 32.56 ± 1.24mg/100 g in ginger. Likewise Ikpeama, Onwuka, and Nwankwo\cite{18} reported that calcium phosphorus and potassium, iron present in turmeric as 0.21 ± 0.01%, 0.63 ± 0.02%, 0.46 ± 0.03%, 0.045 ± 0.02%, respectively.

**Extraction yield of active ingredients: curcumin and gingerol**

Extraction of curcumin Solvents for extraction of active ingredient to extract the active ingredient ethanol and water was used. Solvent extraction is a vital method for the extraction of bioactive compounds influenced by numerous factors like the nature of sample, solvent ratio, time and constant temperature. The mean values presented in Table 4 show that maximum extraction yield of curcumin (0.01870 ± 5.0699 g/100 g) was obtained with 50% ethanol at the 90°C while the minimum (0.01762 ± 3.7733/100 g) extraction yield of curcumin was observed in aqueous solvent at the temperature of 30°C (Figure 1).

The mean value presented in Table 5 demonstrates that maximum extraction yield of gingerol (1.61 ± 0.008g/100g) was observed with 50% ethanol solvent at the 90°C temperature whereas, the minimum (1.32 ± 0.007 g/100 g) extraction yield of gingerol was obtained in water at the 30°C temperature. These results are corroborated with the findings of\cite{19} who reported that at the increased temperature (up to 60°C) curcumin yield was increased and then decreased due to further increased in temperature. The present research work shows higher yields of curcumin and gingerol than the previous studies.\cite{20} It occurs due to the composition of turmeric, and different extraction yield by using the spectrophotometrically analytical techniques. The difference in the results may be due to the use of different analytical techniques for the assessment of bioactive compounds (Figure 2).

**Effects of treatments on extraction of antioxidants turmeric and ginger powder**

**Antioxidant indices of ginger and turmeric extract**

The Mean values of total phenolics (TPC) in turmeric and ginger investigated in this study are presented in (Table 6). It is noticeable from the results that the highest amount of TPC (103.39 ± 0.58) was observed in (TGP) followed by TP with the amount of 76.14 ± 0.70 GAE/100 g while the least amount 69.11 ± 0.33 Table 3.

| Parameters (%) | Ginger | Turmeric |
|----------------|--------|----------|
| Calcium        | 68.28 ± 0.75a | 14.07 ± 0.35b |
| Iron           | 8.42 ± 0.50b  | 19.09 ± 0.33a |
| Potassium      | 128.58 ± 0.52a | 116.6 ± 0.90b |
| Phosphorus     | 5.18 ± 0.26b  | 7.08 ± 0.26a  |
| Magnesium      | 102.67 ± 0.69a | 93.9 ± 0.65b  |
| Manganese      | 2.15 ± 0.10b  | 2.70 ± 0.16a  |

Table 3. Mineral profile.

Table 4. Extraction of curcumin from turmeric.

| Solvent detail | Observation | 30 | 60 | 90 |
|----------------|-------------|----|----|----|
| Water solvent  | X1          | 0.01756 | 0.01745 | 0.01794 |
|                | X2          | 0.01784 | 0.01761 | 0.01788 |
|                | X3          | 0.01772 | 0.01786 | 0.01798 |
|                | Mean        | 0.01763 | 0.01764 | 0.01793 |
| Ethanol solvent| X1          | 0.01856 | 0.01846 | 0.01893 |
|                | X2          | 0.01804 | 0.01814 | 0.01848 |
|                | X3          | 0.01871 | 0.01838 | 0.01869 |
|                | Mean        | 0.01844 | 0.01861 | 0.01870 |

Table 4. Extraction of curcumin from turmeric.
Figure 1. Extraction of curcumin.

Table 5. Extraction of gingerol.

| Solvent detail | Observation | Optimized time intervals (mins) |
|----------------|-------------|---------------------------------|
|                |             | 30 | 60 | 90 |
| Water solvent  |             |    |    |    |
| X1             | 1.3146      | 1.3895 | 1.4142 |
| X2             | 1.3248      | 1.3159 | 1.5125 |
| X3             | 1.3118      | 1.4012 | 1.5628 |
| Mean           | 1.3171      | 1.3689 | 1.4965 |
| Mean ± Variance| 1.32 ± 0.007| 1.368 ± 0.47 | 1.50 ± 0.76 |
| Ethanol solvent|             |    |    |    |
| X1             | 1.4102      | 1.4828 | 1.6028 |
| X2             | 1.4198      | 1.4798 | 1.6158 |
| X3             | 1.4045      | 1.4791 | 1.5987 |
| Mean           | 1.4115      | 1.4806 | 1.6058 |
| Mean ± Variance| 1.41 ± 0.007| 1.48 ± 0.002 | 1.61 ± 0.008 |

Figure 2. Extraction of gingerol.
GAE/100 g was recorded in GP (ginger powder) T2, respectively. Frankel and Meyer[8] stated that the polyphenolics compounds obtained in spices make a good preventive tool of arthritis. Several studies Shan, Cai, Sun, and Corke[21] Wong, Li, Cheng, and Chen[22] reported that phenolic compounds in spices and herbs significantly contribute to their antioxidant properties. Consequently, the elevated total phenolics content of plants extracts result in higher antioxidant activity as reported by Cai, Luo, Sun, and Corke.[23]

Ginger and turmeric are very commonly used dietary spices in Indian cooking both in vegetarian and non-vegetarian preparations. Both of them are cooked at temperatures higher than 100°C. One of the objectives of this study is to assess the antioxidant prospective of crude spice extract. The crude extracts of both of the spices contain more than one antioxidant, so it is the synergistic effect of all the potent antioxidant molecules that cumulatively show their antioxidant activity. The turmeric powder showed significantly higher antioxidant activity, as it is known to have higher monoterpenic abundance in dry powder Wojdyło, Oszmiański, and Czemerys[24] reported that content of TPC in turmeric powder was 825.58 mg GAE/100g and the current study results of are highly consistent with their work.

**DPPH radical scavenging activity**

The mean values for free radical scavenging activity of both turmeric and ginger are presented in [Table 6](#). It is obvious from the results that the maximum value of DPPH was found in TGP (80.16 ± 0.23%) followed by TP (70.38 ± 0.23%), while least of DPPH content (66.04 ± 0.43%) was recorded in GP, respectively. Turmeric and ginger (TGP) exhibited a stronger ability (80.16%) to quench DPPH radicals, than TP (70.38%) and GP (ginger powder) (66.04%) was observed. The results reported in the present study are corroborated with the finding of.[25] The procedure behind the free radical scavenging activity of Polyphenols radicals which decrease of oxidative stress and avoid the onset of diseases.[26] DPPH radical was used as a stable free radical to determine antioxidant activity of natural compounds reported by Öztürk, Aydoğan-Oztürk, Duru, and Topçu.[27] DPPH activity of turmeric powder by extracting from the water and ethanol at different time and temperature.[28]

**Ferric reducing antioxidant power (FRAP)**

The mean values of ferric reducing antioxidant power (FRAP) examined in the study are presented in [Table 6](#). The highest value (47.67 ± 0.19 mg/100 g) of FRAP was observed in TGP (combination of ginger and turmeric), followed by TP (28.16 ± 0.20 mg/100 g) while the least (27.01 ± 0.12 mg/100 g) FRAP content was recorded in GP (ginger powder) respectively. Fuhrman et al.[29] stated that antioxidants present in plants have preservative effects. Normally this preservative effect is greater in the plants with more polyphenolics compounds due to the synergistic impact. It is evident from the results that the turmeric and ginger have high amount of phenolics acid and FRAP that would act as potential therapeutic in the treatment of arthritis (Figure 3).

**Total Flavonoids**

The mean values of total Flavonoids (TFC) content of turmeric ginger drink examined in this study are presented in [Table 6](#). The highest amount of both turmeric and ginger 4.27 ± 0.05 mg/100 g was observed in TGP, followed by TP 3.88 ± 0.25 mg/100 g while least 2.25 ± 0.06 total Flavonoids.

**Table 6. Antioxidant indices of ginger extracts.**

| Treatments | Total phenolics (mg GAE/100g) | FRAP (mg/100g) | DPPH (%) | Total flavonoids (mg CE/100 g) |
|------------|-------------------------------|----------------|----------|---------------------------|
| TP         | 76.14 ± 0.70                  | 28.16 ± 0.20   | 70.38 ± 0.23 | 3.88 ± 0.25 |
| GP         | 69.11 ± 0.33                  | 27.01 ± 0.12   | 66.04 ± 0.43 | 2.25 ± 0.06 |
| TGPA       | 103.39 ± 0.58                 | 47.67 ± 0.19   | 47.67 ± 0.19 | 4.27 ± 0.05 |

TPE: Turmeric Powder extract  
GPE: Ginger Powder extract  
TGPE: turmeric ginger powder extract
content were recorded in GP (ginger powder) respectively. Ghasemzadeh, Jaafar, and Rahmat\cite{30} stated that ginger have a higher amount of antioxidant activity. There is a positive relationship between the TFC and TPC and higher levels of total phenolics compound and total Flavonoids resulted in higher levels of antioxidant activity. Osman, Rahim, Isa, and Bakhir\cite{31} reported similar results about the parameter under study.

**Conclusion**

Both turmeric and ginger powders were found to be rich in bioactive compounds. Turmeric and ginger drinks showed appreciable amounts of Flavonoids, total phenolics, FRAP and DPPH. Both turmeric and ginger are a rich source of nutrients as well as bioactive compounds including proximate parameters, minerals, and antioxidant compounds. Therefore, novel products with supplementation of ginger and turmeric extract should be produced and introduced in the market.

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**References**

[1] Ares, G.; Gimenez, A.; Gambaro, A. Consumer Perceived Healthiness and Willingness to Try Functional Milk Desserts. Influence of Ingredient, Ingredient Name and Health Claim. *Food Qual. Preference*. **2009**, *20*(1), 50–56. DOI: 10.1016/j.foodqual.2008.07.002.

[2] Tapsell, L.-C.; Hemphill, I.; Cobiac, L.; Sullivan, D.-R.; Fenech, M.; Patch, C.-S.; Williams, P.-G. Health Benefits of Herbs and Spices: The Past, the Present, the Future. *2006*, *185*, 4–21.

[3] Potawale, S.; Sinha, S.; Shroff, K.; Dhalawat, H.; Boraste, S.; Gandhi, S.; Tondare, A. Solanum Nigrum Linn: A Phytopharmacological Review. *Pharmacologyonline*. **2008**, *3*, 140–163.
[4] Venkatesh, S.; Reddy, G.-D.; Reddy, B.-M.; Ramesh, M.; Rao, -A.-A. Antihyperglycemic Activity of Caralluma Attenuata. *Fitoterapia*. 2003, 74(3), 274–279.

[5] Rivlin, R.-S. Historical Perspective on the Use of Garlic. *J. Nutr.* 2001, 131(3), 951S–954S. DOI: 10.1093/jn/131.3.951S.

[6] Funk, I.-L.; Oyarzo, J.-N.; Frye, J.-B.; Chen, G.; Lantz, R.-C.; Jolad, S.-D.; Timmermann, B.-N. Turmeric Extracts Containing Curcuminoids Prevent Experimental Rheumatoid Arthritis. *J. Nat. Prod.* 2006, 69(3), 351–355. DOI: 10.1021/np050327z.

[7] Viasan, A.; Nirmala Menon, A.; Madhusudhana Rao, I.; Narayanan, C.; Mathew, A. Chemical Analysis of Some Sultivars of Curcuma Longa Linn. *J. Food Sci. Technol.* 1989, 26(5), 293–295.

[8] Frankel, E.-N.; Meyer, A.-S. The Problems of Using One-dimensional Methods to Evaluate Multifunctional Food and Biological Antioxidants. *J. Sci. Food Agric.* 2000, 80(13), 1925–1941. DOI: 10.1002/1097-0010(200010)80:13<1925::AID-JFST4>3.0.CO;2-4.

[9] AACC. *Approved Methods of Analysis*, 10th ed.; American Association of Cereal Chemists. Inc: St. Paul, MN, 2000.

[10] Singleton, V.-L.; Orthofer, R.; Lamuela-Raventós, R.-M. [14] Analysis of Total Phenols and Other Oxidation Substrates and Antioxidants by Means of Folin-cioalcalteu Reagent. *Methods Enzymol.* 1999, 299, 152–178. Elsevier

[11] Ordonez, A.; Gomez, J.; Vattuone, M. Antioxidant Activities of Sechium Edule (jacq.) Swartz Extracts. *Food Chem.* 2006, 97(3), 452–458. DOI: 10.1016/j.foodchem.2005.05.024.

[12] Müller, L.; Fröhlich, K.; Böhm, V. Comparative Antioxidant Activities of Carotenoids Measured by Ferric Reducing Antioxidant Power (FRAP), ABTS Bleaching Assay (aTEAC), DPPH Assay and Peroxy Radical Scavenging Assay. *Food Chem.* 2011, 129(1), 139–148. DOI: 10.1016/j.foodchem.2011.04.045.

[13] Yuan, Y.; Velev, O.-D.; Lenhoff, A.-M. Mobility of Adsorbed Proteins Studied by Fluorescence Recovery after Photobleaching. *Langmuir*. 2003, 19(9), 3705–3711. DOI: 10.1021/la026368m.

[14] Steel, R.-G.-D.; Torrie, J.-H.; Dickey, D. *Principles and Procedures of Statistics: A Biometrical Approach*, 3rd ed.; McGraw Hill Book Co. Inc.: New York, 1997.

[15] Osabor, V.; Bassey, F.; Umoh, U. Phytochemical Screening and Quantitative Evaluation of Nutritional Values of Zingiber Officinale (ginger). *Am. Chem. Sci. J.* 2016, 8(4), 1–6. DOI: 10.9734/ACJS/2015/16915.

[16] Tanweer, S.; Shahzad, A.; Ahmed, W. Compositional and Mineral Profiling of Zingiber Officinale. *Pak. J. Food Sci.* 2014, 24(1), 21–26.

[17] Ereifej, K.-I.; Feng, H.; Rababah, T.-M.; Taštoush, S.-H.; Al-UAtt, M.-H.; Al-Rabahi, G.; Al-Kasrawi, M. Microbiological Status and Nutritional Composition of Spices Used in Food Preparation. *Food Nutr. Sci.* 2015, 6(12), 1134. DOI: 10.4236/fns.2015.6121118.

[18] Ikpeama, A.; Onwuka, G.; Nwanoko, C. Nutritional Composition of Tumeric (curcuma Longa) and Its Antimicrobial Properties. *Int. J. Sci. Eng. Res.* 2014, 5(10), 1085–1089.

[19] Goyal, R.; Korla, B. Changes in the Quality of Turmeric Rhizomes during Storage. *J. Food Sci. Technol.* 1993, 30, 362–364.

[20] Mandal, V.; Mohan, Y.; Hemalatha, S. Optimization of Curcumin Extraction by Microwave Assisted in Vitro Plant Cell Bursting by Orthogonal Array Designed Extraction Process and HPTLC Analysis. *Pharmacogn. Mag.* 2007, 3(11), 132.

[21] Shan, B.; Cai, Y.-Z.; Sun, M.; Corke, H. Antioxidant Capacity of 26 Spice Extracts and Characterization of Their Phenolic Constituents. *J. Agric. Food Chem.* 2005, 53(20), 7749–7759. DOI: 10.1021/jf05153y.

[22] Wong, -C.-C.; Li, H.-B.; Cheng, K.-W.; Chen, F. A Systematic Survey of Antioxidant Activity of 30 Chinese Medicinal Plants Using the Ferric Reducing Antioxidant Power Assay. *Food Chem.* 2006, 97(4), 705–711. DOI: 10.1016/j.foodchem.2005.05.049.

[23] Cai, Y.; Luo, Q.; Sun, M.; Corke, H. Antioxidant Activity and Phenolic Compounds of 112 Traditional Chinese Medicinal Plants Associated with Anticancer. *Life Sci.* 2004, 74(17), 2157–2184. DOI: 10.1016/j.lfs.2003.09.047.

[24] Wójdylo, A.; Oszmiański, J.; Czemerys, R. Antioxidant Activity and Phenolic Compounds in 32 Selected Herbs. *Food Chem.* 2007, 105(3), 940–949. DOI: 10.1016/j.foodchem.2007.04.038.

[25] Maizura, M.; Aminah, A.; Wan Aida, W. Total Phenolic Content and Antioxidant Activity of Kesum (polygonum Minus), Ginger (zingiber Officinale) and Turmeric (curcuma Longa) Extract. *Int. Food Res. J.* 2011, 18, 2.

[26] Huang, G.; Fang, M.; Wu, Q.; Zhou, L.; Liao, X.; Wong, J. Co-composting of Pig Manure with Leaves. *Environ. Technol.* 2001, 22(10), 1203–1212. DOI: 10.1080/09593332008618207.

[27] Öztürk, M.; Aydoğmuş-Öztürk, F.; Duru, M.-E.; Topçu, G. Antioxidant Activity of Stem and Root Extracts of Rhubarb (rheum Ribles): An Edible Medicinal Plant. *Food Chem.* 2007, 103(2), 623–630. DOI: 10.1016/j.foodchem.2006.09.005.

[28] Kaur, C.; Kapoor, H.-C. -Oxidant Activity and Total Phenolic Content of Some Asian Vegetables. *Int. J. Food Sci. Technol.* 2002, 37(2), 153–161. DOI: 10.1046/j.1365-2621.2002.00552.x.

[29] Fuhrman, B.; Volkova, N.; Rosenblat, M.; Aviram, M. Lycopene Synergistically Inhibits LDL Oxidation in Combination with Vitamin E, Glabridin, Rosmarinic Acid, Carnosic Acid, or Garlic. *Antioxid. Redox Signaling.* 2000, 2(3), 491–506. DOI: 10.1089/1523086050192279.
[30] Ghasemzadeh, A.; Jaafar, H.-Z.; Rahmat, A. Antioxidant Activities, Total Phenolics and Flavonoids Content in Two Varieties of Malaysia Young Ginger (zingiber Officinale Roscoe). *Molecules*. **2010**, *15*(6), 4324–4333. DOI: [10.3390/molecules15064324](https://doi.org/10.3390/molecules15064324).

[31] Osman, H.; Rahim, A.; Isa, N.; Bakhir, N. Antioxidant Activity and Phenolic Content of Paederia Foetida and Syzygium Aqueum. *Molecules*. **2009**, *14*(3), 970–978. DOI: [10.3390/molecules14030970](https://doi.org/10.3390/molecules14030970).