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ARTICLE

Comparison of Antimicrobial Activity, Phytochemical Profile and Minerals Composition of Garlic *Allium sativum* and *Allium tuberosum*

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Abstract *Allium* species are considered to be one of the world's oldest cultivated vegetables. Most commonly used species of garlic in Pakistan and India is *Allium sativum*, while *Allium tuberosum* is mainly consumed and cultivated in China, Southeast Asia, and North-east part of India. The present study was conducted to compare the antimicrobial activity, nutritional value and antioxidant profile of *Allium sativum* and *Allium tuberosum.* The outcome indicates that *Allium tuberosum* have slightly higher antimicrobial activity, higher mineral profile, and enriched in antioxidants in comparison with *Allium sativum.* The highest antimicrobial activity of *Allium tuberosum* was noticed against *Staphylococcus aureus* and *Bacillus subtilis* with 43.9 and 40.7 mm zone of inhibition using 100% extract. *Allium tuberosum* contains high contents of calcium (28.662±.00 mg/100 g), potassium (10.62±0.50) and zinc (59.00±1.00). *Allium tuberosum* also showed higher antioxidant activity (0.24±0.03 mg vitamin C equivalent (VCE)/g fresh weight in ferric reducing antioxidant power assay, 0.18±0.02 mg VCE/g fresh weight in 2,2-diphenyl-1-picrylhydrazyl assay and 1.09±0.12 mg VCE/g fresh weight in 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) assay) in comparison with *Allium sativum.*

Keywords *Allium sativum* · *Allium tuberosum* · antimicrobial activity · comparison · minerals · phytochemical assay

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Introduction

Nutraceutical foods owing to their functional and health perspectives are getting popular in all over the world (Khalid et al., 2011). Traditional plants are the popular therapeutic carrier for nutraceutical foods. Diets based on plant based products elucidate the importance of functional ingredients, these plants include garlic, onion, black cumin, green tea ginger etc. (Fawad et al., 2012). Onion and garlic may perhaps be the first cultivated crops. Their versatility, portability, long storage time and functional attributes are documented since long time (Butt et al., 2009).

Allium family has over 600 members, distributed all over in Europe, North America, Northern Africa and Asia. All of these members have great variation in taste, form, color and visual appearance but close in biochemical, phytochemical and nutraceutical contents (Benkeblia and Lanzotti, 2007). Most commonly used species of garlic in Pakistan and India is *Allium sativum*, whereas *Allium tuberosum* species is mainly consumed and cultivated in China, Southeast Asia, and North-east part of India (Fenwick and Hanley, 1990).

Garlic is a rich source of numerous chemical compounds mainly sulphur compounds like: ajoene, allicin, alliin, allyl disulfides, allyl sulfides, allyl trisulfides, cycloalliin, cysteine, cysteine sulfoxides, cystine, diallyl sulfides, dimethyl sulfides, disulfides, glutathione, methionine, methyl sulfides, pseudoscordinine, scordinine, sulfanes, tetrathiol, thiosulfinates, and trisulfides (Lanzotti, 2006; Choudhary, 2008; Butt et al., 2009). Similarly, it also contains high levels of phosphorous, calcium and iron. It is

considered to be the rich source of riboflavin, thiamine, nicotinic acid and vitamin C. In addition, garlic contains the minerals selenium and germanium (Touloupakis and Ghanotakis, 2011). Phytochemicals including linalool, citral, á-phellandrene, geraniol, propionic aldehyde, and valeraldehyde are also reported in garlic (Milner, 1996). These phytochemicals are effective in reducing the risk of various diseases like cancer (Butt et al., 2009), coronary heart disease (Touloupakis and Ghanotakis, 2011), obesity, hypercholesterolemia (Choudhary, 2008), diabetes type 2, hypertension, cataract, and disturbances of various types of gastrointestinal tract (Touloupakis and Ghanotakis, 2011).

There are many garlic products and are processed by different methods such as, freeze drying, distillation, maceration in oil and various types of alcoholic extractions (Staba et al., 2001). These methods produce various functional compounds that have beneficial effects in human body (Tattelman, 2005). These biological functions include antimicrobial activity against *Escherichia coli, Shigella sonnei, Shigella flexneri, Helicobacter pylori, Shigella dysenteriae* and various strains of *Proteus, Staphylococcus* and *Pseudomonas* (Davis et al., 2003; Touloupakis and Ghanotakis, 2011). It is reported that garlic is effective against human cytomegalovirus, influenza B, Herpes simplex virus type 1, Herpes simplex virus type 2, parainfluenza virus type 3, vaccinia virus, vesicular stomatitis virus, and human rhinovirus type 2 (Harris et al., 2001).

In a human body, garlic acts as anticarcinogenic agents and effective against colon, stomach, prostate and various other cancers mainly of sulphur and selenium contents (Sigounas et al., 1997; Dong et al., 2001; Durak et al., 2003; Li et al., 2004). Similarly, it has also anti-inflammatory and anti-thrombotic activity (Srivastava and Tyagi, 1993) and effective against atherosclerosis, aging and various cancer (Cavalieri and Rogan, 1992; Salvemini and Botting, 1993).

Different types of extracts were used to evaluate the antioxidant properties of *Allium* components (Prasad et al., 1995) these extracts insinuated that the thiosulfinates or related organosulfur components are primarily responsible for the observed antioxidant effects (Siegers et al., 1999), although other endogenous components, such as phenolics, may also have antioxidant properties (Benkeblia, 2005). The organosulfur compounds of garlic have potential antioxidant activity and these compounds stimulate certain enzymes in liver such as glutathione peroxidase, glutathione transferase, catalase, superoxide dismutase, among others. There was no previous study that compares the antimicrobial activities of *Allium sativum* and *Allium tuberosum.* To further refine the benefits of *Allium* species, the present study was conducted to compare the antimicrobial activity, physico-chemical parameters, mineral contents, antioxidants and phenolic contents of *Allium sativum* and *Allium tuberosum.*

Materials and Methods

Procurement of raw material. The local garlic (*Allium sativum*) and Chinese garlic (*Allium tuberosum*) were collected from local market, and their taxonomic status was verified from Department of Botany, Pir Mehr Ali Shah Arid Agriculture University, Pakistan. The raw materials were washed and cleaned in order to remove the adhered dirt, dust and other foreign material. The garlic cloves were separated and peeled out for further analysis and preparation of aqueous garlic extract.

Preparation of aqueous garlic extract. About 200 g of each washed spice was crushed using electrical Juicer (National, MK-8710), pre disinfected with 70% ethanol and dried in Laminar flow hood. The mashed material was sieved through a fine mesh cloth predisinfected with ethanol and also dried in the Laminar flow hood. This extract was considered as the 100% concentrated extract. The concentrations of 75, 50, and 25% were made by diluting the concentrated extract with appropriate volume of Milli-Q water.

Antimicrobial activity against test strains. The *in-vitro* activity of different garlic extracts were assayed against various bacterial strains. All the test strains acquired from American type culture collection (ATCC) and were maintained on Nutrient agar slants (Oxoid Ltd., UK) at 4°C. The identification of these strains were confirmed according to the techniques described in Manual of Clinical Microbiology (Murray et al., 2007). The bacterial strains include *Staphylococcus aureus* ATCC 6538, *Enterococcus faecalis* ATCC 49452, *Escherichia coli* ATCC 25922, *Salmonella typhimurium* ATCC 13311, *Pseudomonas aeruginosa* ATCC 27853, and *Bacillus subtilis* ATCC 19659.

Purity testing of each organism. Each organism was inoculated from working culture of Nutrient Broth (Merk Chemicals, Germany) on the respective selective medium as a control and for confirmation of purity i.e. *Pseudomonas aeruginosa* on Pseudomonas Cetrimide Agar (Oxoid, CM0579), *Salmonella typhimurium* on Xylose Lysine Deoxycholate Agar (Oxoid, CM0469), *Staphylococcus aureus* on Mannitol Salt Agar (Oxoid, CM0085), *Enterococcus faecalis* on Slanetz & Bartley (Oxoid, CM0377), *Escherichia coli* on Eosin Methylene Agar (Oxoid, CM0069), *Bacillus subtilis* on Mannitol Egg Yolk Polymyxin Agar (Oxoid, CM0929) and was incubated at 37°C for 24 h.

Evaluation of antimicrobial activity. After incubation, one colony of each bacterium was inoculated into 5 mL nutrient broth and incubated for further 4–6 h at 37°C with rigorous shaking (150 rpm). The inocula cell density was standardized by comparing its turbidity with McFarland No.1 standard. The test culture was spread evenly on the surface of solidified Mueller Hinton Agar (MHA) (Oxoid, CM0337) with a sterile cotton swab. Wells were made in the MHA agar plate using a sterile cork borer of 6 mm. With the help of a sterile micropipette tips 0.1 mL of each garlic extract of both *Allium sativum* and *Allium tuberosum* were poured in the wells. The plates were incubated at 37°C for 24 h. After incubation, the diameter of resulting zone of inhibition was measured and the average values were recorded. Each antimicrobial assay was performed in at least triplicate.

Comparison with standard antibiotics. Standard discs (7 mm

diameter) of ciprafloxicin 'CIP' (5 μg) and tetracycline 'TE' (30 μg) obtained from Oxoid Ltd, were used as positive controls for antimicrobial activity against different Gram-positive and Gram-negative bacteria.

Proximate analysis and physico-chemical analysis. The garlic samples were analyzed to determine total ash content, crude protein, crude fat, crude fiber, moisture content, and nitrogen free extract according to the protocols mentioned in AACC (2000). Physico-chemical analysis of *Allium sativum* and *Allium tuberosum* like total soluble solids, total acidity and pH were estimated according to their respective protocols (AOAC, 2003). Total soluble solids of aqueous garlic extract was estimated by hands refractometer (TAMCO, Model No. 90021, Japan) and results were interpreted as percent soluble solids in °Brix. pH was recorded directly by calibrated pH meter (InoLab 720, Germany) following the method described in AOAC (2003) while total acidity of garlic extracts were determined by titrating it against 0.1 N sodium hydroxide solution until to persistent pink color following the method of AOAC (2003).

Minerals analysis. *Allium sativum* and *Allium tuberosum* samples were subjected to mineral analysis following the methods of AOAC (2003). Sodium and potassium were determined on Flame Photometer-410 (Sherwood Scientific Ltd., UK), whereas calcium, iron, zinc, copper, magnesium, and manganese were analyzed on atomic absorption spectrophotometer (Varian AA240, Australia).

Sample preparation for antioxidant and phenolic contents. Two grams of homogenized sample were added with 10 mL of 95% ethanol and vortex for 1 min for proper mixing. The mixture was filtered with 0.45 μm cellulose acetate filter and the filtrate was used for ferric reducing antioxidant power (FRAP), 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS), 2,2-diphenyl-1-picrylhydrazyl (DPPH), and total phenolic content assays.

FRAP assay. The FRAP was assessed according to the procedure described by Benzie and Strain (1999). Freshly prepared FRAP reagent (6 mL) was mixed with 100 μL of the filtered garlic extract. The absorbance was measured at 593 nm after 30 min of incubation period at 37°C. FRAP values were calculated by comparing with standard curve of 15 μg ascorbic acid. The obtained values were reported as mg VCE per gram of fresh weight.

ABTS radical cation decolorization assay. ABTS assay was performed according to the procedure of Re et al. (1999). ABTS cations were produced by reacting 7 mM ABTS stock solution with 2.45 mM potassium persulphate. The reaction mixture was kept in a dark room for 15 h prior to use. The adjusted absorbance (0.70) of diluted reacting mixture and 95% ethanol (1:1) were measured at 734 nm. Garlic extract (100 μL) was mixed with 6 mL of diluted ABTS solution. The decrease in absorbance was recorded after 1 min. The obtained value was used to calculate ABTS values by comparing with standard curve of (20 μg) ascorbic acid, and the results were reported as mg VCE per gram of fresh weight.

DPPH free radical scavenging activity. The DPPH activity was measured according to the method of Brand-William et al. (1995) with slight modifications. DPPH solution (0.8 mM) in 95% ethanol was used to observe the activity. Garlic extract (100 μL) was first diluted with deionized water and 95% ethanol (1:1) before adding DPPH. The decrease of absorbance was recorded at 1 min intervals. The obtained value was used to calculate DPPH activity by comparing with standard curve of (40 μg) ascorbic acid, and the results were reported as mg VCE per gram of fresh weight.

Total phenolic content. The Folin-Ciocalteau micro method was used to estimate total phenolic content. 60 μL garlic was diluted with deionized Milli-Q water to 4.8 mL, followed by addition of 300 μL of Folin-Ciocalteau reagent. After 10 min, 900 μL of 20% sodium carbonate solution was added to the resultant mixture, and the solution was kept at 40°C for 30 min. The absorbance was observed at 765 nm. Gallic acid (50 μg) was used as reference standard, and the results were reported as mg gallic acid equivalent per gram of fresh weight.

Statistical analysis. Each experiment was performed in triplicate on *Allium sativum* and *Allium tuberosum* extracts. A completely randomized design was used as a statistical tool and least significant difference was determined according to the method described by Steel and Torrie (1980).

Results and Discussion

Evaluation of antimicrobial activity. Significant differences (p <0.05) of antimicrobial activities of both garlic species were evaluated; *Allium tuberosum* was highly effective against the test microorganisms (Table 1A, B, and C). The extract concentration also affects the antimicrobial activity. *Allium* extract (100%) have more lethal effect, followed by 75, 50, and 25% the least effective. *Pseudomonas aeruginosa* showed resistance against extracts of both *Allium sativum* and *Allium tuberosum*, with no zone of inhibition. The highest antimicrobial activity of *Allium tuberosum* was noticed against *Staphylococcus aureus* and *Bacillus subtilis* with 43.9 and 40.7 mm zone of inhibition using 100% extract, respectively, followed by 75, 50, and 25% (Fig. 1A). The least antimicrobial activity was noticed for *Enterococcus faecalis* with zone of inhibition of 20.07 mm in 100% extract, whereas, *Pseudomonas aeruginosa* showed resistance against all concentrations evaluated.

The antimicrobial activity of *Allium sativum* was not as effective as that of *Allium tuberosum.* Strains *Salmonella typhimurium, S. aureus,* and *B. subtilis* showed significant difference (p <0.05) in all extracts from (25 to 100%), with maximum zone of inhibition in *S. aureus* at 51.8 mm and *B. subtilis* at 45.9 mm, respectively. The least antimicrobial activity was noticed for *Enterococcus faecalis* with zone of inhibition of 18.1 mm in 100% extract (Fig. 1B), whereas, *Pseudomonas aeruginosa* show complete resistance against all concentrations (Table 1B). There was no significant

Table 1 (A) Antimicrobial activity (mm) of *Allium tuberosum*. Values in the same column sharing the same letters are not significantly different at 95% probability level. (B) Antimicrobial activity (mm) of *Allium Sativum*. Values in the same column sharing the same letters are not significantly different. (C) Zone of inhibition (mm) of standard antibiotics

(A)

Extract (%)	Extract (mL)	*P. aeruginosa*	*E. coli*	*E. faecalis*	*S. typhimurium*	*S. aureus*	*B. subtilis*
25%	0.1 mL	R	18.8±1.50^{D}	15.7±1.62^{D}	13.0±1.34^{D}	26.5±2.30^{D}	25.8±2.38^{D}
50%	0.1 mL	R	21.7±1.55^{C}	16.3±1.43^{C}	16.4±1.66^{C}	30.9±2.54^{C}	30.0±2.45^{C}
75%	0.1 mL	R	23.9±1.34^{B}	18.4±1.66^{B}	21.3±1.70^{B}	39.3±2.68^{B}	36.5±2.86^{B}
100%	0.1 mL	R	32.2±1.60^{A}	20.7±1.76^{A}	24.8±1.80^{A}	43.9±2.39^{A}	40.7±3.82^{A}

R = Resistant.

(B)

Extract (%)	Extract (mL)	*P. aeruginosa*	*E. coli*	*E. faecalis*	*S. typhimurium*	*S. aureus*	*B. subtilis*
25%	0.1 mL	R	21.4±1.42^{C}	11.6±1.50^{C}	16.1±1.66^{D}	34.4±2.32^{D}	29.5±1.70^{D}
50%	0.1 mL	R	25.3±1.23^{B}	14.5±1.43^{B}	18.8±1.47^{C}	38.9±2.60^{C}	34.7±2.76^{C}
75%	0.1 mL	R	28.8±1.51^{A}	17.1±1.64^{A}	21.1±1.80^{B}	45.9±2.85^{B}	42.8±2.66^{B}
100%	0.1 mL	R	30.1±2.43^{A}	18.1±1.29^{A}	25.7±1.90^{A}	51.8±2.93^{A}	45.9±2.71^{A}

R = Resistant.

(C)

Antibiotic Disc	Disc Potency (µg)	*P. aeruginosa*	*E. coli*	*E. faecalis*	*S. typhimurium*	*S. aureus*	*B. subtilis*
CIP	30 µg	32.8±2.20	36.1±2.25	22.9±2.29	34.8±2.36	30.4±2.32	42.1±3.23
TE	5 µg	8.7±1.30	23.9±1.27	19.9±1.26	13±1.40	23.1±2.35	31.6±3.21

CIP = Ciprofloxacin, TE = Tetracycline.

difference (p <0.05) of antimicrobial activity in *E. coli* and *Enterococcus faecalis.*

Kundakoviæ et al. (2011) studied the antimicrobial activity of garlic bulb powder, allicin and the lozenge with 15% of garlic powder. They reported very high antimicrobial activity against *B. subtilis.* Ziarlarimi et al. (2011) concluded the minimum inhibitory concentration (MIC) of garlic with aqueous extract of 5% were effective against *E. coli.* Similarly, Eja et al. (2011) proved the antimicrobial activity of *Allium sativum* (MIC >16 mm) against *E. coli* and *Staphylococcus aureus.* Fresh garlic and garlic powder, through their combined antioxidant and antimicrobial effects, are potentially useful in preserving meat products (Sallam et al., 2004; Gheisari and Ranjbar, 2012).

Proximate analysis of *Allium sativum and Allium tuberosum.* *Allium tuberosum* and *Allium sativum* samples were analyzed for various quality attributes having significant difference in moisture contents and ranging between 64.07±0.81 and 62.19±0.82% respectively (Table 2). Similar type of difference was observed in crude fiber contents. Higher fiber contents were found in *Allium sativum* (2.05±0.03%) in comparison to 0.60±0.03% in *Allium tuberosum*. The difference among moisture and fiber may be due to climatic pattern and growing conditions. No significant differences (p >0.05) were observed for dry matter, crude fat, crude protein, and ash content (Table 2).

The results are comparable with the previous findings of Nwinuka et al. (2005). They reported the analysis of garlic samples for moisture, crude protein, crude fat, total carbohydrates and ash contents as 4.88±0.13, 17.35±0.00, 0.68±0.01, 73.03±0.06, and 4.06±0.10%, respectively, on dry basis. Similarly, Odebunmi et al. (2010) analyzed *Allium sativum* and concluded the moisture, dry matter, crude fat, crude protein, ash, and crude fiber ranged 66.57±1.58, 33.43±1.58, 0.52±0.09, 7.87±0.76, 1.33±0.04, and 0.73±0.19% respectively. Our results are also in agreement with these studies. Likewise, Sampath et al. (2010) also observed that garlic composition contained approximately 84.09% water, 1.53% inorganic matter, and 13.38% organic matter, while garlic leaves contained 87.14% water, 1.59% inorganic matter, and 11.27% organic matter.

Physco-chemical analyses of *Allium tuberosum and Allium sativum.* There was no significant difference (p >0.05) in pH and total acidity in extracts of *Allium tuberosum* and *Allium sativum* (Table 3). The pH ranged from 5.370.15 and 5.330.15 in *Allium tuberosum* and *Allium sativum*, respectively. There was significant difference in total soluble solids (TSS) of *Allium tuberosum* and *Allium sativum.* The TSS was higher in *tuberosum* (17.950.80) in comparison to *A. sativum* (16.450.85). These results are in agreement with those of Ahmed and Shivhare (2001). They recorded pH and acidity of garlic paste as 4.1 and 0.35%, respectively.

Mineral composition of *Allium tuberosum and Allium sativum.* Significant difference (p <0.05) in mineral contents of *Allium tuberosum* and *Allium sativum* were observed (Table 4). *Allium tuberosum* contained higher mineral content as compare to *Allium sativum.* Except copper (Cu), *Allium sativum* contained less amount of minerals. The sodium (Na), calcium (Ca), iron (Fe), phosphorus (P), potassium (K), zinc (Zn), Cu, manganese (Mn),

Table 2 Proximate analysis of *Allium tuberosum* and *Allium sativum*

Varieties	Moisture	Dry Matter	Crude Fat	Crude Protein	Ash	Crude Fibre
Allium tuberosum	64.07±0.81^{A}	33.47±0.94^{A}	0.44±0.02^{A}	8.83±0.22^{A}	1.36±0.05^{A}	0.60±0.03^{B}
Allium sativum	62.19±0.82^{B}	32.73±0.84^{A}	0.48±0.02^{A}	8.80±0.25^{A}	1.48±0.04^{A}	2.05±0.03^{A}

Values in the same column sharing the same letters are not significantly different at 5% probability level.

Table 3 pH, Total soluble solid and Total acidity of *Allium tuberosum* and *Allium sativum*

Varieties	pH	Total acidity	Total soluble solids
Allium tuberosum	5.37±0.15^{A}	0.43±0.01^{A}	17.95±0.80^{A}
Allium sativum	5.33±0.15^{A}	0.49±0.01^{A}	16.45±0.85^{B}

Values in the same column sharing the same letters are not significantly different at 5% probability level.

and magnesium (Mg) ranged 4.50±0.35, 28.66+2.00, 4.40+0.29, 10.62±0.50, 59.00±1.00, 0.86±0.01, 0.013±0.00, 0.014±0.00, and 3.77±0.20 mg/100 g, respectively, in *Allium tuberosum.*

The results of minerals profile are comparable with the previous findings of Otunola et al. (2010). They reported that Na, Ca, Fe, P, K, Zn, Cu, Mn, and Mg in garlic samples were 4.10±0.14, 26.30±0.14, 5.29±0.08, 10.19±0.26, 54.00±1.40, 0.34±0.17, 0.001±0.00, 0.001±0.00, and 4.10±0.14 mg/100 g, respectively. Similarly, Bangash et al. (2011) also reported Ca, Na, K, Mg, Fe, Cu, Zn, Mn, and Cr ranged 30, 23, 70, 26, 5, 0.33, 3.05, 0.66, 0.25 mg/100 g in *Allium sativum.*

Total phenolic and antioxidant contents of *Allium tuberosum* and *Allium sativum.* There was a significant difference among total phenolic and antioxidant contents of *Allium tuberosum* and *Allium sativum*. *Allium tuberosum* (Fig. 2) contained higher phenolic contents (0.61±0.10 mg GAE/g fresh weight) in comparison to *Allium sativum* (0.39±0.10 mg as GAE/g fresh weight) (Table 5). *Allium tuberosum* has antioxidant activity of 0.24±0.03 mg VCE/g fresh weight in FRAP assay, 0.18±0.02 mg VCE/g fresh weight in DPPH assay and 1.09±0.12 mg VCE/g fresh weight in ABTS assay.

The results of antioxidant activity of garlic extracts with different analytical methods are shown in Table 5. The extraction methods and analytical procedures play a significant role in evaluating the antioxidant activities. FRAP assay measures the ability to reduce ferric tripyridyltriazine (Fe^{3+}-TPTZ) to a ferrous form (Fe^{2+}-TPTZ) of garlic extracts (Benzie and Strain, 1999). Different extracts have power to reduce different cations, Wang et al. (1998) reported that some compounds that have ABTS scavenging activity might not have DPPH scavenging activity based upon the action of different cations, whereas Arts et al. (2004) showed that in some products, ABTS scavenging reaction may have a reducing potential due to the reaction with the remaining ABTS radicals.

Aguirrezábal et al. (2000) compared the antioxidant effect of

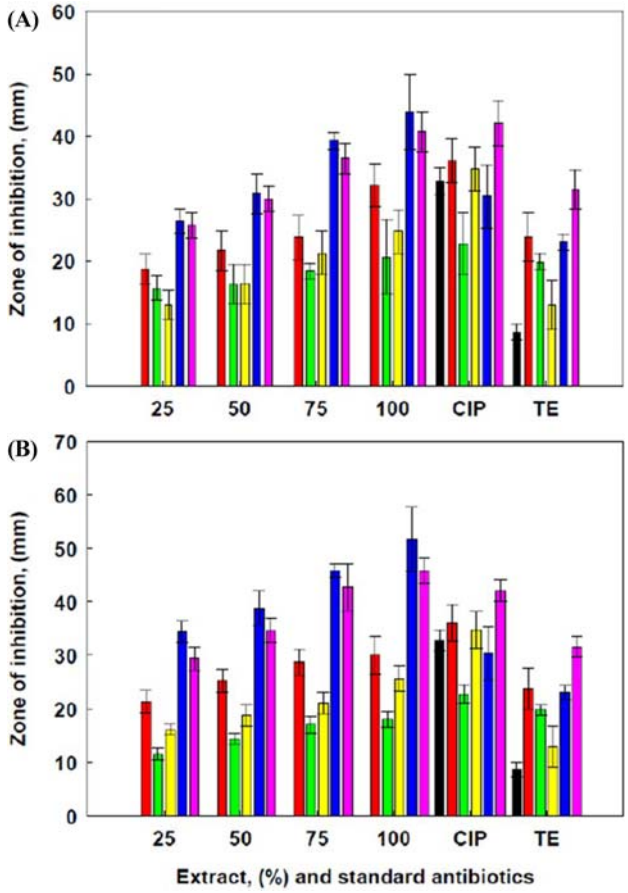

Fig. 1 Comparison of antimicrobial activity (A) *Allium tuberosum* and (B) *Allium sativum*. Red bar = *E. coli*, Green bar = *E. faecalis*, Yellow bar, *S. typhimurium*, Blue bar = *S. aureus*, Pink bar = *B. subtilis* and Black bar = *P. aeruginosa*.

Table 4 Mineral composition of *Allium tuberosum* and *Allium sativum*

Varieties	Na	Ca	Fe	P	K	Zn	Cu	Mn	Mg
Allium tuberosum	4.50±0.35^{A}	28.66+2.00^{A}	4.40+0.29^{A}	10.62±0.50^{A}	59.00±1.00^{A}	0.86±0.01^{A}	0.013±0.00^{A}	0.014±0.00^{A}	3.77±0.20^{A}
Allium sativum	4.06+0.32^{B}	24.33±1.95^{B}	3.93±0.21^{B}	9.86±0.55^{B}	50.66±1.20^{B}	0.53±0.01^{B}	0.010±0.00^{A}	0.010±0.00^{B}	2.63±0.25^{B}

Values in the same column sharing the same letters are not significantly different at 5% probability level.

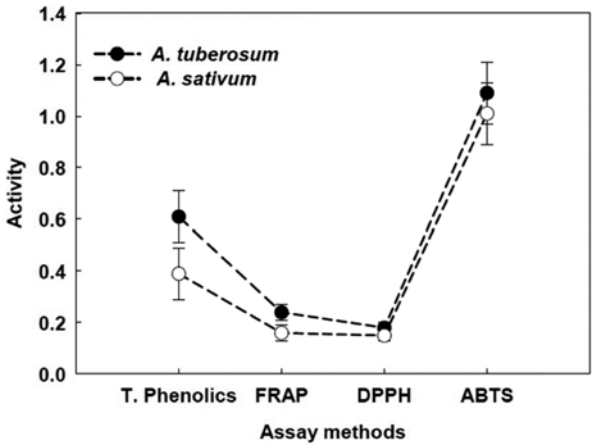

Fig. 2 Phyochemicals assay of *Allium tuberosum* and *Allium sativum.*

Table 5 Total phenolic and antioxidants contents of *Allium tuberosum* and *Allium sativum*

Varieties	Total Phenolic	FRAP	DPPH	ABTS
Allium tuberosum	0.61 ± 0.10^{A}	0.24 ± 0.03^{A}	0.18 ± 0.02^{A}	1.09 ± 0.12^{A}
Allium sativum	0.39 ± 0.10^{B}	0.16 ± 0.03^{B}	0.15 ± 0.02^{B}	1.01 ± 0.12^{B}

Values in the same column sharing the same letters are not significantly different at 5% probability level.

garlic with a mixture of different salts including nitrate, nitrite, and ascorbic acid) in dry sausage. They observed that garlic was as effective as the mixture of additives in inhibiting lipid oxidation. Tepe et al. (2005) investigated the *in-vitro* antioxidant activities of five *Allium* species extracts, *Allium nevsehirense*, *Allium sivasicum*, *Allium dictyoprosum*, *Allium scrodoprosum* subsp. *Rotundum*, and *Allium atroviolaceum*. They showed that non-polar sub-fractions of garlic extract did not show any antioxidant potential, whereas the polar sub-fractions exhibited marked activity.

In conclusion, *Allium tuberosum* and *Allium sativum* have significant inhibitory activity against a variety of potentially pathogenic microorganisms. This antimicrobial activity is due to the various antioxidants, phenolic compounds, and minerals. *Allium tuberosum* have slightly higher antimicrobial activity as compare to *Allium sativum*. In terms of proximate analysis, mineral profile, phenolic properties, and antioxidant activity *Allium tuberosum* gave better results and were far more effective in comparison with *Allium sativum*.

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