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Antioxidant and Antimicrobial Potential of Locally Sun Dried Garlic and Ginger Powder Available in District Layyah, Punjab, Pakistan

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Abstract: In the last few decades, the awareness among populations escalated about the safety issues of food additives that also resulted in global shift of consumers towards utilization of products with natural ingredients. Generally, spices like garlic and ginger are widely used in the cuisines and traditional medicines. In the present research, dried garlic and ginger powder were purchased from local market of Layyah and their antioxidant and antimicrobial potential was assessed. The results indicated the varied nutritional composition e.g. garlic contains less amounts of total sugars and higher amounts of ascorbic acid as compared to inverse trends in ginger for same traits. Both garlic and ginger contain significant amounts of macro and micro minerals. Dried ginger powder showed higher antioxidant potential as compared to the garlic. Ginger contains higher amounts of total polyphenols 826.74±37.01 mg GAE/100 g as compared to the garlic 297.80±10.72 mg GAE/100 g. Dried ginger powder showed higher inhibition of 63.74±2.23% as compared to 44.12±1.89% for garlic powder. The antimicrobial potential of the dried garlic and ginger powder yielded varied results as garlic was slightly more effective antimicrobial agent than ginger with the exception of campylobacter. However, the results regarding antimicrobial potential are based on the unidentified strains of microorganisms isolated from local fruit juices. Overall, the results indicated the potential of dried garlic and ginger powder as natural antioxidants and antimicrobial agents.

Key words: Antioxidants, antimicrobials, spices, garlic, ginger

INTRODUCTION

In the last few decades, nutritionists diverted their attention from developing food pyramids to diet-health linkages. Similarly, scientists working in the domain of medical and pharmaceutical sciences also started advising people to be particular careful with reference to their diet. Several studies also indicated the global shift of consumers towards natural products (Butt and Sultan, 2013; Sultan *et al*., 2014). These foods have multiple health benefits especially against lifestyle related disorders including diabetes mellitus and cardiovascular disorders. Moreover, most of these functional foods contain antioxidants that help in scavenging free radicals being produced in the body. Natural compounds found in fruits, cereals, vegetables and spices hold antioxidant activity. Carotenoids, tocopherols, polyphenols, anthocyanins, alkaloids, aged glycated peptides are among the most important natural antioxidants (Amarowicz *et al*., 2004). The use of antioxidant substances hinder or decrease the development of oxidative reactions (Kulisic *et al*., 2004) due to their free radicals scavenging ability. Supplementation of natural antioxidants is always desirable to modulate the process of free radicals production. The process of oxidation also occurs in different food products thus responsible for quality deterioration. The quality defects include loss in color, flavor, texture and nutritional value. The process of lipid peroxidation is by the superoxide radical or by hydroxyl radicals. For this reason, antioxidants are extremely significant as they can be used as a preventive agent (Tlili *et al*., 2013).

Spices are important component of human diet and used as condiments in nearly all recipes in the cuisines. They are usually plant based materials and added to the food products to give some specific aroma and flavor to enhance the acceptability. The commonly used spices include garlic, ginger, red and black pepper, cumin, caraway, turmeric, fenugreek, etc. The spices are also effective in improving the health of the individuals due to

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presence of several bioactive components. Among spices, garlic and ginger are also widely used in traditional and modern medicines. Garlic contains several sulfur containing bioactive compounds including allicin, diallyl disulphide, diallyl trisulphide and ajoene (Butt *et al*., 2009). Garlic has been claimed to be effective against various health disorders especially against cardiovascular disorders and oxygen free radicals mediated diseases. Garlic and its bioactive components are also important for enhancing the immunity and controlling diabetes complications. The garlic and its components are reported to be effective antimicrobial agents. Like garlic, ginger (*Zingiber officinale*) is the tropical plant found in abundance in Asia (Oktay *et al*., 2003). Ginger belongs to family of Zingiberaceae and its main active components are phenolic substances i.e., gingerol, shogaol and zingiberene. Ginger is also reported to be effective in various health disorders including gastrointestinal, cardiovascular and diabetes mellitus (Ghasemzadeh *et al*., 2010). Most of these bioactive components hold antioxidant and antimicrobial potential that is helpful in mitigating the complications of diabetes mellitus and cancer insurgence (Ahmad *et al*., 2006; Bushra *et al*., 2009).
Some of them are used in the fresh form but most of time spices are sun-dried to enhance the shelf life. In the present study, the biochemical composition of dried garlic and ginger powder was determined. The focus of the present research was to determine the antioxidant and antimicrobial potential of the selected condiments. The outcomes of the present research are really helpful in declaring the garlic and ginger powder as health promoting entities thus consumers should include them in their daily diet in appreciable quantities. The limitation of the present research includes the utilization of unidentified microbial strains thus later study should be conducted to check the influence of these nutritionally rich commodities on identified food borne pathogens.

MATERIALS AND METHODS

The research study was conducted in the Laboratory of Food Science and Technology at Faculty of Agricultural Sciences and Technology and Microbiology Lab, Faculty of Veterinary Sciences, B.Z. University, Multan. Initially, the locally sun-dried garlic and ginger powder was purchased from main market, Layyah, Punjab, Pakistan. The samples were sieved through mesh and impurities were removed. The samples were further ground into a fine powder for analytical purpose.

Proximate analysis: The sun-dried garlic and ginger powder were analyzed for moisture, ash, crude protein, crude fat, crude fiber and nitrogen free extract (NFE). The moisture content was estimated according to AACC Method No. 44-01 (AACC, 2000) by drying the sample in a hot air oven at 105±5°C till constant weight. Ash was estimated by direct incineration of sample taken in crucible according to AACC method 08-01 (AACC, 2000). The crude protein contents were determined using the percentage of nitrogen in the sample using Method No: 46-13 mentioned in AACC (2000). The crude protein percentage was calculated by multiplying nitrogen with a factor 6.25. Crude fat content was determined by slurring the samples with hexane (1:6 ratio) in Soxhlet apparatus according to AACC method 30-10 (AACC, 2000). The crude fiber was estimated by taking fat free sample and digesting first with 1.25% H_2SO_4, followed by 1.25% NaOH solutions. The residue was calculated and ignited in a muffle furnace at 550°C till white residue left. Fiber percentage was calculated according to the AACC method 32-10 (AACC, 2000). The nitrogen free extract (NFE) on dry basis was calculated according to the following expression:

NFE (%) = 100 - [Total ash + crude protein + crude fat + crude fiber (%)]

Mineral contents: Minerals like Na, K, Ca, Fe and Zn were determined by following procedures of AOAC (1990) using dry ash method. Ash was dissolved in acidic solution and sodium, potassium and calcium were determined through flame photometer and rests of the minerals like iron, zinc, etc. were determined using Atomic Absorption Spectrophotometer.

Total sugars and vitamin C: Total sugar is determined by volumetric method (the Lane-Eynon method) as mentioned in AOAC (1990). Vitamin-C content was estimated using 2, 6-dichlorophenolindophenol dye according to the prescribed method of AOAC (1990).

Antioxidant potential: In this phase, the antioxidant rich extracts of dried garlic and ginger were prepared by slurring the samples with aqueous ethanol for a period of one hour. The facilities of National Institute of Food Science and Technology, University of Agriculture, Faisalabad were used in this context as mentioned in the acknowledgement section. Briefly, the samples were slurred with aqueous ethanol using arbitrary shaker and centrifuged for 15 min at 4000 rpm. The supernatant was further filtered with Whatman filter paper No. 1 filter paper. The solvent from the supernatant was separated at 50°C in a rotary vacuum evaporator (EYELA, N-N series, Japan). The extracts were further analyzed for their antioxidant potency through different parameters like total phenolic contents, β-carotene bleaching assay (antioxidant activity) and DPPH assay (free radical scavenging activity) as discussed below.

Total phenolic content: Total phenolic contents (TPC) were measured according to the method of Mustafa *et al*. (2010). Firstly, 5 mL of DMSO dissolved 5 mg of freeze-dried extracts of herbal noodles. Then, 0.5 mL of the resulting aliquot was added to 1 mL of 50% Folin-Ciocalteau reagent and incubated for 3 min at room temperature (20-25°C). Next, 3 mL of 1% Na_2CO_3 was added to the mixture, thoroughly vortex-mixed and incubated for further 30 min. Absorbance of the mixture was read at 760 nm, using a spectrophotometer (Thermo Scientific Genesys 20, USA). Results were expressed as milligrams of gallic acid equivalents per 100 g of noodle sample (mg GAE/g noodles).

Antioxidant activity: Antioxidant activity based on coupled oxidation of β-carotene and linoleic acid was evaluated by using a modification of the method described by Taga *et al.* (1984). The antioxidant activity (AA) was expressed as % inhibition relative to the control using following equation.

DPPH free radicals scavenging assay: The DPPH assay was carried out using the method described by Prabhasankar *et al.* (2009) with slight modification. Briefly, 0.10 mM of DPPH was dissolved in 100 mL of 99.9% ethanol. Stock solutions of extracts (0.5 mL) were dissolved in 100 mL distilled water on the day before analysis to allow the extract to be finely dissolved. A 2 mL DPPH solution was mixed with 2 mL of dissolved extracts in the test tubes and shaken well for at least 15 sec. Finally, 2 mL of 99.9% ethanol was mixed with 2 mL of DPPH solution (used as blank) and test tubes were kept in the dark for 1 h. The absorbance of blank, control and all the samples were taken at 517 nm. The scavenging effect (%) was calculated according to the following equation:

$$\text{Inhibition DPPH } (\%) = \frac{(\text{Abs DPPH} - \text{Abs sample})}{\text{Abs DPPH}} \times 100$$

Abs DPPH is the absorbance of the DPPH solution without extracts Abs sample is the absorbance of sample solution.

Antimicrobial potential of extracts: Antimicrobial potential of dried garlic and ginger extracts were evaluated against the bacterial strains i.e., *E-coli*, *Salmonella*, *Campylobacter*, *Listeria*, *Coliform*, *Clostridium*, *Staphylococcus* bacteria and fungi like *Candida*. The microorganisms were isolated and identified by the method described by Koneman *et al.* (1999) from the fruit juices and limitations of the present research include utilization of unidentified strains of microorganism. The results for isolation are not mentioned in the research project as this work was carried out in collaboration with Dr. Atif Nisar Ahmad. Later, the minimum inhibitory concentrations (MIC) of dried garlic and ginger against these bacterial genera were determined and mentioned as under. Briefly, isolated strains were cultured on their specific media i.e. Maconkeys agar (*E-coli*), *Salmonella-shigella* agar (*Salmonella and Shigella* spp), Blood agar (*Pseudomonas*, *Listeria* and *Streptococcus* spp.), Manitol salt agar (*Staphylococcus* spp.), Modified charcoal cefeperazone deoxycolate agar (*Campylobacter* spp.), Different-reinforced clostridium medium (*Clostridium* spp.), Sabouraud agar (*Candida* spp.). The agar disc diffusion method was used to determine the antimicrobial activity. Sterile discs (6 mm, Hi-media, India) were loaded with 50µl of (30 mg/mL) garlic and ginger powder extract dissolved in 5% dimethyl sulfoxide (DMSO). Bacterial suspensions were also diluted to match the 0.5 McFarland standard scales (approximately 1.5x108 CFU/mL). Further, Muller Hinton Agar (MHA) was poured into petri dishes to give a solid plate and inoculated with 100 µL of suspension containing 1.5x1 08 CFU/mL of bacteria. The plates were then incubated at 37°C for 24 to 36 h and inhibition zones diameter around each of the discs were measured and recorded. Minimum inhibition concentrations of the plant extracts was tested by the checkerboard assay method (Collee *et al.*, 1989).

Statistical analysis: The data obtained for each parameter was analyzed statistically to determine the level of significance. The dried garlic and ginger powder were further compared through two sample t-test following the protocols outlined by Steel *et al.* (1997). Statistical analyses were run using Statistical Analysis System (SAS Institute, Cary, NC) version 9.1 and Microsoft Excel 2007.

RESULTS AND DISCUSSION

The results regarding the proximate composition (Table 1) indicated that the dried garlic and ginger contains nearly similar amount of moisture i.e., 7.07±0.11 and 9.56±0.60, respectively. However, garlic contains higher contents of protein and carbohydrates (17.85±0.77 and 63.33±3.10%) as compared to ginger (8.71±0.12 and 57.24±2.95%, respectively. In contrast, significantly higher values for fat, ash and crude fiber were observed for dried ginger powder. The results regarding total sugars and ascorbic acid indicated that garlic contains less amounts of sugars and higher amount of ascorbic acid as compared to ginger that contains higher amounts of total sugars and less amount of ascorbic acid. The results are in contrast with nitrogen free extract as total sugars are less in garlic and higher in ginger. It might be due to the presence of higher amounts of dietary fiber in garlic as compared to ginger (Butt *et al.*, 2009).

The analysis of chemical composition is an important tool to assess the nutritional quality and to clarify their role in human diet. Protein and fats have vital roles in the development of human body and both of these two

Table 1: Means for nutritional composition of dried ginger and garlic powder

	Selected dried spices	
Parameters	Garlic	Ginger
Moisture	7.07±0.11[b]	9.56±0.60[a]
Protein	17.85±0.77[a]	8.71±0.12[b]
Fats	0.73±0.03[b]	4.25±0.07[a]
Ash	3.57±0.19[b]	5.36±0.18[a]
Crude fiber	8.74±0.17[b]	15.32±0.10[a]
NFE	63.33±3.10[a]	57.24±2.95[a]
Total sugars	2.32±0.06[b]	3.59±0.05[a]
Vitamin C	1.17±0.04[a]	0.68±0.00[b]

*NFE: Nitrogen free extract (It represent the carbohydrate fraction)

Table 2: Means for macro-mineral profile of dried ginger and garlic powder

	Selected dried spices	
Parameters	Garlic	Ginger
Calcium (Ca)	70.49±3.55[b]	131.04±3.24[a]
Magnesium (Mg)	68.83±4.24[b]	227.23±7.90[a]
Phosphorous (P)	366.54±8.18[a]	183.86±3.04[b]
Potassium (K)	1067.37±52.26[b]	1443.28±56.45[a]
Sodium (Na)	56.41±2.79[a]	27.91±1.48[b]

*NFE: Nitrogen free extract (It represent the carbohydrate fraction)

Table 3: Means for micro-mineral profile of dried ginger and garlic powder

	Selected dried spices	
Parameters	Garlic	Ginger
Iron (Fe)	5.88±0.36[b]	19.70±1.21[a]
Zinc (Zn)	2.70±0.11[b]	3.82±0.18[a]
Copper (Cu)	0.51±0.03[a]	0.46±0.02[a]
Manganese (Mn)	0.90±0.01[b]	33.58±1.77[a]

Table 4: Means for antioxidant potential of dried ginger and garlic powder

	Selected dried (sp.)	
Parameters	Garlic	Ginger
TPP (mg GAE/100 g)	297.80±10.72[b]	826.74±37.01[a]
DPPH (% inhibition)	44.12±1.89[b]	63.74±2.23[a]
β-carotene (% inhibition)	45.51±1.57[a]	52.29±1.84[a]

*TPP (total polyphenols) **GAE: Gallic acid equivalent

**DPPH Diphenyl picryl hydrazine

components along with carbohydrates are important energy reservoir for balanced human metabolism. The ash represents the inorganic components of foods especially minerals. Usually dietary fiber plays an important role in immunonutrition and food synergy. The dietary fiber has significant and imperative value for proper functionality of digestive system. The presence of dietary fiber in appreciable amounts is associated with better growth of microflora residing in intestinal tract along with several health benefits including cholesterol lowering potential. In the present study, the sun-dried garlic and ginger were used thus the lower moisture contents were obvious. Generally, lower moisture contents in spices correspond to higher shelf life. Sharma and Prasad (2001) analyzed that moisture content percentage in garlic that was quite different to

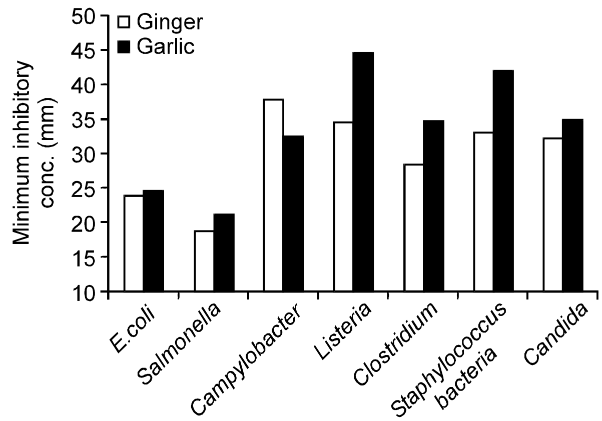

Fig. 1: Minimum Inhibitory Concentration (mm) of medicinal plant against various isolated bacterial strains

the values observed in the present study. According to Odebunmi *et al.* (2009), garlic contains 1.3±0.2, 8.75, 0.52±0.09 and 0.73±0.19% of ash, protein, fat and fiber contents. Same scientists reported that ginger contains 2.54±0.54, 7.87±0.76, 5.62±0.75 and 2.93±0.05% of aforementioned traits, respectively.

The results regarding macro-minerals contents indicated the presence of calcium, magnesium, phosphorous, potassium and sodium (Table 2). Garlic contains higher amounts of phosphorus and sodium, while dried ginger powder contains higher amounts of calcium, magnesium and potassium. Like macro-minerals, the ginger contains higher amounts of micro-minerals with the exception of copper that was present in slightly higher amounts in garlic (Table 3). The both categories of minerals i.e., macro and micro-minerals are indispensable for proper well being of humans. Their balanced intake from food is essential for modulation of cellular metabolism. The findings of mineral percentages in present study are in agreement with previous research studies (Otunola *et al.*, 2010; Gulzar *et al.*, 2012). Moreover, these results are also in harmony with the limits defined by World Health Organization (WHO).

Numerous research studies have reported that garlic and ginger contain appreciable amounts of antioxidants. In the present study, dried ginger showed higher antioxidant potential as compared to the garlic (Table 4). Ginger contains higher amounts of total polyphenols 826.74±37.01 mg GAE/100 g as compared to garlic 297.80±10.72 mg GAE/100 g. The presence of higher amounts of total polyphenols resulted in higher DPPH free radical inhibition. Dried ginger powder showed higher inhibition of 63.74±2.23% as compared to 44.12±1.89% for garlic powder. The results regarding β-carotene assay showed slight similar inhibition as 45.51±1.57% for garlic powder as compared to

52.29±1.84% inhibition with ginger powder. The results are in agreement with some previous research e.g., Panpatil *et al.* (2013) explicated that garlic and ginger possess significant antioxidant potential and even comparable with commercial natural antioxidants like tocopherols and vitamin C. The results for antioxidant activity of ginger and garlic are also in concordance with Kubra *et al.* (2011) and Calin-Sanchez *et al.* (2013), respectively. Regarding ginger, Jolad *et al.* (2004) identified more than 60 compounds in fresh ginger that can be grouped into two broader categories, i.e., volatiles and non-volatiles. The functional ingredients of ginger like gingerols possess substantial antioxidant activity as determined by various antioxidant assays. *In vitro*, zingerone scavenged O_2 and OH and suppressed lipid peroxidation (Dugasani *et al.*, 2010). In contrast to ginger, chemistry of garlic is very complex and is not easy to understand due to volatile nature of substances. However, garlic contains components like diallyl sulfides, ajoene, etc. that hold antioxidant and antimicrobial activities (Chung *et al.*, 2006).

The findings of the present study indicated that both garlic and ginger exhibit considerable antimicrobial activities. The results were expressed as minimum inhibitory concentration (mM) of plant extracts for isolated bacterial strains. The garlic extract showed quite similar results for clostridium and candida species while ginger showed comparable results for staphylococcus and candida species. The highest value was observed for garlic against listeria species. In contrast, the minimum value was noted for ginger against salmonella species. These results are in concordance with the observations of Panpatil *et al.* (2013). They observed the antimicrobial activity of garlic and ginger for *Staphylococcus aureus* (125 mg/mL), *E. coli* (175 mg/mL) and *Salmonella* (150 mg/mL).

Conclusion: The health-promoting perspectives of garlic and ginger are well known. Both these commodities used as condiments exhibit the ability to treat a wide range of ailments including immunonutrition and anti-inflammatory responses. In the present study, the results were quite conclusive that both dried garlic and ginger possess significant antioxidant activity and antimicrobial potential. For meticulousness, the antimicrobial potential should be checked against identified strains for warranting its commercial applications.

REFERENCES

AACC, 2000. American Association of Cereal Chemists. 2000. Approved Methods of the AACC. St. Paul, MN: AACC.

Ahmad, N., S. Sulaiman, N.A. Mukti, N.A. Murad, N.A.A. Hamid and Y.A.M. Yusof, 2006. Effects of ginger extract (*Zingiber officinale* Roscoe) on antioxidant status of hepatocarcinoma induced rats. Mal. J. Biochem. Mol. Biol., 14: 7-12.

Amarowicz, R., R. Pegg, P. Rahimi-Moghaddam, B. Barl and J. Weil, 2004. Free-radical scavenging capacity and antioxidant activity of selected plant species from the Canadian prairies. Food Chem., 84: 551-562.

AOAC, 1990. Official Methods of Analysis. The Association of Official Analytical Chemists. 15th ed. Arlington, USA.

Bushra, S., A. Farooq and A. Muhammad, 2009. Effect of extraction solvent/technique on the antioxidant activity of selected medicinal plant extracts. Molecules., 14: 2167-2180.

Butt, M.S. and M.T. Sultan, 2013. Selected functional foods for potential in diseases treatment and their regulatory issues. Int. J. Food Prop., 16: 397-415.

Butt, M.S., M.T. Sultan, M.S. Butt and J. Iqbal, 2009. Garlic; nature's protection against physiological threats. Crit. Rev. Food Sci. Nutr., 49: 538-551.

Calin-Sanchez, A., A. Figiel, A. Wojdy'o, M. Szarycz and A.A. Carbonell-Barrachina, 2103. Drying of garlic slices using convective pre-drying and vacuum-microwave finishing drying: kinetics, energy consumption and quality studies. Food Bioprocess Technol., 6: 855-858.

Chung, L.Y., 2006. The antioxidant properties of garlic compounds: allyl cysteine, alliin, allicin and allyl disulfide. J. Med. Food., 9: 205-213.

Collee, J.G., J.P. Duguid, A.G. Fraser and B.P. Marmion, 1989. Practical Medical Microbiology (13th ed.), Churchill Livingstone, Edinburgh, UK.

Dugasani, S., M.R. Pichika, V.D. Nadarajah, M.K. Balijepalli, S. Tandra and J.N. Korlakunta, 2010. Comparative antioxidant and anti-inflammatory effects of [6]-gingerol, [8]-gingerol, [10]-gingerol and [6]-shogaol. J. Ethnopharmacol., 127: 515-20.

Otunola, G. A., O. B. Oloyede, A.T. Oladiji and A.J. Afolayan, 2010. Comparative analysis of the chemical composition of three spices-*Allium sativum* L. *Zingiber officinale* Rosc. and *Capsicum frutescens* L. Commonly Consumed in Nigeria. Afr. J. Biotechn., 41: 6927-6931.

Ghasemzadeh, A., H.Z.E. Jaafar and A. Rahmat, 2010. Antioxidant activities, total phenolics and flavonoids content in two varieties of Malaysia young ginger (*Zingiber officinale* Roscoe). Molecules., 15: 4324-4333.

Gulzar, I.I. M.H. Lutfia, O.B. Shirwan and S.F. Sirwan, 2012. Effect of heavy metal content of some common spices available in local markets in Erbil city on human consumption. Raf. J. Sci., 23: 106-114.

Jolad, S.D., R.C. Lantz, A.M. Solyom, G.J. Chen, R.B. Bates and B.N. Timmermann, 2004. Fresh organically grown ginger (*Zingiber officinale*): composition and effects on LPS-induced PGE2 production. Phytochem., 65: 1937-1954.

Koneman, E.W., S.D. Allen, W.M. Janda, P.C. Schreckenberger and W.C. Winn, Jr, 1999. Color Atlas and Text Book of Diagnostic Microbiology. (5th ed) Philadelphia, Lippincott.

Kubra, I.R., K. Ramalakshmi and L.J.M. Rao, 2011. Antioxidant enriched fractions from *Zingiber officinale* Roscoe. E-J. Chem., 8: 721-726.

Kulisic, T., A. Radonic, V. Katalinic and M. Milos, 2004. Use of different methods for testing antioxidative activity of oregano essential oil. Food Chem., 85: 633-640.

Mustafa, R.A., A. Abdul Hamid, S. Mohamed and F.A. Bakar, 2010. Total phenolic compounds flavonoids and radical scavenging activity of 21 selected tropical plants. J. Food Sci., 75: 28-35.

Odebunmi, E.O., O.O. Oluwaniyi and M.O. Bashiru, 2009. Comparative proximate analysis of some food condiments. J. App. Sci. Res., 6: 272.

Oktay, M., Y. Gulcin and O.Y. Kufrevioglu, 2003. Determination of in vitro antioxidant activity of fennel (*Foeniculum vulgare*) seed extracts. LWT-Food Sci. Technol., 36: 263-271.

Sharma, G.P. and S. Prasad, 2001. Drying of garlic (*Allium sativum*) by microwave-hot air combination. J. Food Eng., 50: 99-105.

Panpatil, V.V., S. Tattari, N. Kota, C. Nimgulkar and K. Polasa, 2013. *In vitro* evaluation on antioxidant and antimicrobial activity of spice extracts of ginger, turmeric and garlic. J. Pharmacogn. Phytochem., 2: 143-148.

Prabhasankar, P., P. Ganesan, N. Bhaskar, A. Hirose, N. Stephen, L.R. Gowda, M.H. osokawa and K. Miyashita, 2009. Edible Japanese seaweed wakame (*Undaria pinnatifida*) as an ingredient in pasta: Chemical functional and structural evaluation. Food Chem., 115: 501-508.

Steel, R.G.D., J.H. Torrie and D. Dickey, 1997. Principles and Procedures of Statistics. A biometrical approach. 3rd ed. McGraw Hill Book Co Inc. New York.

Sultan, M.T., M.S. Butt, M.M.N. Qayyum and H.A.R. Suleria, 2014. Immunity: Plants as effective mediators. Crit. Rev. Food Sci. Nutr., 54: 1298-1308.

Taga, M.S., E.E. Miller and D.E. Pratt, 1984. China seeds as source of natural lipid antioxidation. J. Am. Oil Chem. Soc., 61: 928-931.

Tlili, N., W. Elfalleh, H. Hannachi, Y. Yahia, A. Khaldi, A. Ferchichi and N. Nasri, 2013. Screening of natural antioxidants from selected medicinal plants. Int. J. Food Prop., 16: 1117-1126.