

Research Article

Bioactive Compounds and Antioxidant Activity of Common Vegetables and Spices Available in Bangladesh

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Abstract: Giving priority to health-promoting components of plant origin foods, the present investigation is carried out to quantify the levels of bioactive compounds and antioxidant capacity of common vegetables and spices available in Bangladesh. Total polyphenol, flavonoid, anthocyanin contents and antioxidant activity were investigated on seven vegetable i.e., cauliflower, cabbage, carrot, bitter gourd, cucumber, lemon, tomato and three spices i.e., onion, garlic and turmeric in this study. The highest total polyphenol content was found in bitter gourd 87.9±4.6 mg GAE/g of extract and the lowest was found in cabbage 18.7±0.19 mg GAE/g of extract. Total flavonoid content was varying from 28.99 to 133.6 mg QE/g of extract whereas cauliflower has the lowest and onion has the highest content. Anthocyanin the color compound of vegetable was found highest in turmeric and lowest in cauliflower. Consistently, antioxidant capacity was highest in lemon 192.7±0.97 µmol TE/g of extract and lowest in carrot 104.2±0.26 µmol TE/g of extract. The result showed a correlation between phenolic content and antioxidant activities of vegetables and spices. This study provides novel information about common vegetables and spices bioactive composition, which is essential for the understanding of their nutraceutical potential and future application in the food processing industry.

Keywords: Anthocyanin, antioxidant capacity, flavonoid, polyphenol, spices, vegetables

INTRODUCTION

Rapid economic development, mechanization and market globalization across the world have led to enormous changes in diets and lifestyles of peoples. The requirement for transport and a long shelf life guide to the need for the modification of the natural forms of foods. Frying is a very old method of cooking and is now prominent all across the world and is a common method to produce processed food with increased durability. But when fats or oils are heated to high temperatures, as they are with deep-frying, they can become oxidized, creating free radicals (Khanum and Thevanayagam, 2017). The most alarming issue is increased the formation of oxygen radicals, which may result in an attack of different biomolecules such as lipids of bio membranes, DNA and other proteins, may be related to age-related diseases. Uncontrolled production of oxygen-derived from free radicals, is involved in the onset of many diseases such as Cardiovascular Diseases (CVD), diabetes, cancer,

rheumatoid arthritis, as well as in the degenerative process associated with aging, including Parkinson's and Alzheimer's diseases and cause death and disability to millions of people (Ali *et al.*, 2008; Di Matteo and Esposito, 2003). A possible way to fight these diseases is to improve our body's antioxidant defenses (Hossain and Rahman, 2011). Antioxidants, AH, can either delay or inhibit the initiation step by reacting with a lipid radical or inhibit the propagation step by reacting with peroxy or alkoxy radicals. Recently, many epidemiological studies suggested that the consumption of natural antioxidants such as polyphenol-rich food, fresh fruits, vegetables or teas have protective effects against the aforesaid diseases and its protection has partly been ascribed due to the presence of several components as vitamins, flavonoids, anthocyanins and other phenolics compounds (Steffen *et al.*, 2003; Scalbert *et al.*, 2005).

Bioactive compounds are extra-nutritional constituents of foods that have antioxidant, anticarcinogenic, anti-inflammatory and antimicrobial

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properties and provide health benefits beyond the basic nutritional value (Aljaghthmi *et al.*, 2018). Bioactive compounds have the affinity to alter the cellular formation of animate things. Nowadays the attention is focused on the functional components of these chemical constituents or metabolites plants origin food products (Quirós-Sauceda *et al.*, 2014). Besides their direct antioxidant activity, they can be linked to the indigestible component of foods (i.e., fiber fractions), thereby failing to be absorbed in the small intestine of healthy individuals and reaching the colon intact, where they become available by bacterial microflora and promote an antioxidant environment (Manach *et al.*, 2005; Quirós-Sauceda *et al.*, 2014). Plant-based foods such as fruit, vegetables and whole grains, which contain significant amounts of bioactive phytochemicals, may provide desirable health benefits beyond basic nutrition to reduce the risk of chronic diseases (Pandey and Rizvi, 2009; Ahmed and Ali, 2013; Rocchetti *et al.*, 2017). In the last decades, special attention has been paid towards edible plants, especially those that are rich in secondary metabolites and nowadays, there is an increasing interest in the antioxidant activity of such phytochemicals present in the diet.

Vegetables and spices have consumed by people all over Bangladesh for cooking, industrial and restaurant use but scientific data regarding their functional components such as polyphenols, flavonoids, anthocyanins and antioxidants are not common. Vegetables and spices can play a vital role in maintaining public health because of their various health-promoting components (Hossain *et al.*, 2014). In addition, research on bioactive compounds and antioxidant activity of fresh vegetables and spices is still in scarce in Bangladesh. Limited research has been conducted on nutritional composition and microbial quality in Bangladesh. The present study was carried out to investigate bioactive compounds and antioxidant activity of fresh vegetables and spices available in Bangladesh.

MATERIALS AND METHODS

Samples collection: Vegetable such as *Brassica oleracea L.* (Cauliflower), *Brassica oleracea L.* (Cabbage), *Daucuscarota L.* (Carrot), *Momordicacharantia L.* (Bitter Gourd), *Cucumissativus L.* (Cucumber), *Citrus limon L.* (Lemon), *Solanumlycopersicum L.* (Tomato) and spices such as *Allium cepa L.* (Onion), *Allium sativum L.* (Garlic) and *Curcuma longa L.* (Turmeric) samples were obtained from different local market of Chittagong city, Bangladesh. 250 g of each sample (n = 30) was randomly collected and transported to the laboratory.

Extract preparation: Samples were washed with water and chopped into small pieces with sharp knives. Then transferred into respective beakers added with absolute ethanol and left to shake on a shaker for 72 h at room

temperature. Solvent was separated from the residue by straining. The filtrates were collected and stored at room temperature while the residues were re-extracted twice, each time with fresh solvent. Finally, all the filtrates were combined and evaporated under reduced pressure at 60°C using a rotary evaporator to obtain the crude extracts. The crude extracts were weighed and stored at 4°C until further analysis.

Determination of Total Polyphenol Content (TPC):

Total Polyphenol Content (TPC) of the vegetable and spice extracts was determined according to the Folin-Ciocalteu method described by Parthasarathy *et al.* (2009) with slight modifications. Stock solutions (1 mg/mL) of extracts were prepared and 0.3 mL of extracts were pipetted into a cuvette containing 1.5 mL diluted FC reagent (1:10). The solutions were mixed thoroughly and left for 3 min at room temperature. Then 1.5 mL of sodium carbonate (7.5%) solution was added and again incubated at room temperature for 60 min. The absorbance was read at wavelength 765 nm using a UV-VIS Spectrophotometer (UV-2600, Shimadzu Corporation, USA) and ethanol was used as the blank. For quantification of TPC concentration, a gallic acid standard curve was plotted with different standard solutions of gallic acid i.e., 0.02, 0.04, 0.06, 0.08 and 0.10 mg/mL. The absorbance of the vegetable extract was compared gallic acid standard curve. TPC was calculated and expressed as milligrams of Gallic Acid Equivalents (GAE) per gram of extracts (mg GAE/g).

Determination of Total Flavonoid Content (TFC):

Total Flavonoid Content (TFC) of the vegetable and spice extracts was determined using the aluminum chloride colorimetric method described by Chang *et al.* (2002) but with slight modifications. Stock solution (1 mg/mL) of extracts were prepared and aliquots of 0.5 mL of diluted extract mixed with 1.5 mL of 95% ethanol in a cuvette. Then 0.1 mL of 10% aluminum chloride, 0.1 mL of 1 mol/L potassium acetate and 2.8 mL of distilled water were added to the mixture in the cuvette. The mixture left at room temperature for 30 min. The absorbance was read at wavelength 415 nm in UV-visible spectrophotometer (UV-2600, Shimadzu Corporation, USA) and 10% aluminum chloride substituted with distilled water of the same amount were used as the blank. Quercetin dissolved in 80% ethanol to make standard solutions (0.025, 0.050, 0.075 and 0.100 mg/mL). Total flavonoid content in the sample was estimated by comparing absorbance of the sample extracts with a quercetin standard curve. TFC calculated and expressed as milligrams Quercetin Equivalents (QE) per gram of extract (mg QE/g).

Determination of Total Anthocyanin Content (TAC):

Total Anthocyanin Content (TAC) of the

vegetable and spice extracts will where be determined colorimetrically following the method described with slight modifications (Selim *et al.*, 2008). Stock solutions of vegetable extracts were prepared in ethanol. 3 mL of the extract solution was pipetted into a cuvette and intensity of color was measured at wavelength 520 nm using UV-VIS spectrophotometer (UV-2600, Shimadzu Corporation, USA). Ethanol was used as a blank. TAC was calculated and expressed as milligrams per 100 g (mg/100 g) using the following equation:

$$\text{TAC} = \text{Absorbance of sample} \times \text{DF} \times 100 / \text{m} \times \text{E}$$

Where DF stands for dilution factor; m means the weight of sample used to make a stock solution; E refers to extinction coefficient (55.9).

Determination of antioxidant capacity: Antioxidant capacity of the extracts were determined using DPPH assay as the method described by Brand-Williams *et al.* (1995) and AzlimAlmey *et al.* (2010) with slight modifications. 6 mg of DPPH was dissolved in 100 mL methanol to prepare Methanolic DPPH solution. An aliquot (0.5 mL) of methanolic solution of extract containing different concentrations of 0.10, 0.20, 0.30, 0.40, 0.60 and 0.80 mg/mL were added to 2.5 mL of methanolic DPPH solution. The mixture was gently shaken and left for 30 min in dark at room temperature. The absorbance was read at wavelength 517 nm using UV-VIS spectrophotometer (UV-2600, Shimadzu Corporation, USA). Control prepared by mixing 1 mL of methanol with 2 mL of DPPH solution while methanol was used as a blank. The scavenging activity was measured as the decrease in absorbance of the samples in comparison with the DPPH standard solution. Antioxidant capacity based on the DPPH free radical scavenging ability of extracts calculated using the following equation:

$$\% \text{ inhibition} = \frac{1 - \text{Absorbance of sample}}{\text{Absorbance of control}} \times 100\%$$

Trolox used as standard and TEAC compound (Trolox equivalent antioxidant capacity) (range of 0 to 200 µM) was used for the calibration standard curve.

The results were expressed in µmol of Trolox equivalents per gram of powder on a dry weight (DW) basis (µmol TE/g).

Statistical analyses: The obtained data were stored in Microsoft Excel 2013 and then all statistical analyses were performed using R Statistical Software (version 3.4.1; R Foundation for Statistical Computing, Vienna, Austria).

RESULTS AND DISCUSSION

Polyphenols, flavonoids and anthocyanins are bioactive components of food with plants and animal origin and show various beneficial health-promoting activities in humans. Table 1 showed their content in extracts of common vegetables and spices in Bangladesh.

Total polyphenol contents: Total polyphenol content of the extracts that were analyzed varies between 18.7±0.19 and 87.9±4.6 mg/g GAE. In the current study, Bitter gourd (87.9±4.6 mg/g GAE), had significantly higher TPC than the other samples followed by Garlic 85.7±2.0 mg/g GAE, Turmeric 53.8±3.89 mg/g GAE, Onion 44.8±2.7 mg/g GAE, Tomato 37.5±0.91 mg/g GAE, Lemon 36.1±0.74 mg/g GAE, Cauliflower 35.1±0.26 mg/g GAE, Carrot 28.9±1.6 mg/g GAE, Cucumber 22.2±1.21 mg/g GAE. The lowest total phenolic content was found in Cabbage 18.7±0.19 mg/g GAE. The obtained data on the total phenolic values of these vegetables and spices are scarce in the available literature and the present findings were comparable with Kähkönen *et al.* (1999), Proteggente *et al.* (2002), Lutz *et al.* (2015) and Kabir *et al.* (2016).

Total Flavonoid Content (TFC): The result of total flavonoid contents of samples extract is given in Table 1. The total flavonoid contents varied from 28.99 to 133.60 mg QE/g of extract. The flavonoid content of onion extract is much higher compared to others, while cauliflower extracts have lower flavonoid content compared to others. These results for total flavonoids contents are compatible with others research on

Table 1: Total phenolic, flavonoid and anthocyanins contents of common vegetables and spices in Bangladesh

Sample		Total Phenolic Content (TPC) (mg GAE/g)	Total Flavonoid Content (TFC) (mg QE/g extract)	Total Anthocyanin Content (TAC) (mg TA/100 g)
Cauliflower	<i>Brassica oleracea L.</i>	35.1±0.26	28.99±0.3	0.19±0.03
Cabbage	<i>Brassica oleracea L.</i>	18.7±0.19	44.84±0.24	0.46±0.00
Carrot	<i>Daucuscarota L.</i>	28.9±1.6	59.67±1.11	0.79±0.04
Bitter Gourd	<i>Momordicacharantia L.</i>	87.9±4.6	70.69±2.32	1.35±0.04
Cucumber	<i>Cucumissativus L.</i>	22.2±1.21	24.84±0.03	0.69±0.04
Lemon	<i>Citrus limon L.</i>	36.1±0.74	48.99±2.61	0.32±0.15
Tomato	<i>Solanumlycopersicum L.</i>	37.5±0.91	84.84±0.28	1.02±0.00
Onion	<i>Allium cepa L.</i>	44.8±2.7	133.60±3.01	0.46±0.07
Garlic	<i>Allium sativum L.</i>	85.7±2.01	94.84±1.89	0.73±0.18
Turmeric	<i>Curcuma longa L.</i>	53.8±3.89	62.84±1.23	3.16±0.40

Data are presented as mean values±standard deviation of triplicates

Table 2: Antioxidant activity of common vegetables and spices in Bangladesh

Sample		Antioxidant capacity (DPPH) ($\mu\text{mol TE/g}$)
Common name	Scientific name	
Cauliflower	<i>Brassica oleracea L.</i>	188.5 \pm 1.8
Cabbage	<i>Brassica oleracea L.</i>	175.1 \pm 0.15
Carrot	<i>Daucuscarota L.</i>	104.2 \pm 0.26
Bitter gourd	<i>Momordicacharantia L.</i>	155.7 \pm 1.47
Cucumber	<i>Cucumissativus L.</i>	135.1 \pm 1.17
Lemon	<i>Citrus limon L.</i>	192.7 \pm 0.97
Tomato	<i>Solanumlycopersicum L.</i>	121.1 \pm 1.30
Onion	<i>Allium cepa L.</i>	146.6 \pm 0.89
Garlic	<i>Allium sativum L.</i>	122.9 \pm 1.22
Turmeric	<i>Curcuma longa L.</i>	107.6 \pm 2.39

Data are presented as mean values \pm standard deviation of triplicates.

vegetables and spices (Lutz *et al.*, 2015; Kabiret *al.*, 2016).

Total Anthocyanin Content (TAC): Anthocyanins, water-soluble antioxidant pigments, are responsible for most of the red, blue and purple colors of vegetables. In this current study, the pigmented turmeric (3.16 \pm 0.40 mg TA/100 g) contained higher levels of anthocyanins compared to the other vegetables (Table 1). In other studies, the TAC of vegetable varieties has been reported to range between 4.1 and 256.5 mg/100 g (Goufo and Trindade, 2014). Although cauliflower 0.19 \pm 0.03 mg TA/100 g anthocyanin content is lower than what has been previously reported in other studies. The difference of anthocyanin content with other studies may be due to environmental and soil conditions. As analyzed vegetables and spices are the plethora of anthocyanin, consumption of anthocyanin rich food will reduce the risk of development of cancers, cardiovascular diseases, neurodegenerative diseases and diabetes (Scalbert *et al.*, 2005).

Antioxidant activity: The total antioxidant activity, which reflected the ability of the extracts to inhibit the bleaching of b-carotene, was measured by their ability to DPPH (Table 2). The results demonstrated statistical differences between the antioxidant capacities of vegetables in Bangladesh. Among these samples, total antioxidant capacity was found in the following order: Lemon > Cauliflower > Cabbage > Bitter Gourd > Onion > Cucumber > Garlic > Turmeric > Carrot. Carrot had the highest antioxidant activity compared to the other vegetables. Furthermore, antioxidant activity results from this study show that significant differences can be observed between pigmented and nonpigmented vegetables. From the results obtained in this study, we can deduce that the lemon had a free radical scavenging ability higher than others. A correlation between phenolic content and antioxidant activity has been found. The correlation between TPC and antioxidant activity in vegetables has also been reported by Ninfali *et al.* (2005), Lim and Lee (2013), Shofian *et al.* (2011), Chatthongpisut *et al.* (2015) and Rahman *et al.* (2016). The differences between the results obtained from this study compared to the previous findings may be due to

the differences in species cultivation of the vegetables and spices used and differences in the extraction methods during analysis. Antioxidant activity might be influenced by environmental factors i.e., climatic growth conditions, growth, ripening stage, temperature, duration of storage and thermal treatment.

CONCLUSION

In this study, for the first time, the antioxidant activity in relation to the polyphenol content in common vegetables and spices of Bangladesh were determined. Profiling of total polyphenol, total anthocyanin, total flavonoid content and antioxidant activity gives consumer clear idea about the important source of polyphenols. The knowledge emerged from the study will improve the branch of food science and nutrition. Polyphenol-rich vegetables and spices could be used in food or in medicinal materials to replace synthetic antioxidants which are about to be restricted owing to their side effects such as carcinogenesis and will minimize expenses of anti-oxidative drugs. However, there were some limitations in this study such as storage time may affect the rate of loss of quality of bioactive compounds. Additionally, processing and preservation technique might have potential effects of bioactive compounds and antioxidant capacity, those must need to take consideration in further research. Studies of potential carcinogenic hazards associated with the samples were not identified.

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