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PHYTOCHEMICAL COMPOSITION OF FOUR SELECTED VEGETABLE SPICES COMMONLY CONSUMED IN MALAWI

Chatepa LEC[1]*, Masamba KG[2], Ngwira A[1], Kumwenda FD[1] and E Munthali[1]

Lesten Chatepa

*Corresponding author email: lecchatepa@yahoo.com

[1]Basic Science Department, Faculty of Agriculture, Lilongwe University of Agriculture and Natural Resources, Bunda College, P.O. Box 219, Lilongwe, Malawi

[2] Food Science and Technology Department, Faculty of Food and Human Sciences, Lilongwe University of Agriculture and Natural Resources, Bunda College, P.O. Box 219, Lilongwe, Malawi

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ABSTRACT

Spices, regardless of source, play an important role in enhancing or improving flavor of foods or dishes. In this study, determination of phytochemical composition with respect to total phenolic compounds, antioxidant capacity and vitamin C was conducted in four selected vegetable spices consumed in Malawi, namely *Allium cepa L*, *Allium sativum L*, green bell pepper (*Capsicum annum L*.) and *Zingiber officinale.* Results showed that total phenolic composition, in mg GAE/100 g, was highest in *Zingiber officinale* rhizomes (326.5±0.39) followed by *Allium cepa L*. (169.7±0.00), green bell pepper (124.9±0.20) and *Allium sativum L*. (72.72±0.39), respectively. Results further showed that *Zingiber officinale* had the highest antioxidant capacity and reducing power and the lowest vitamin C content, in the range of 21.78±0.21 mg AAE/100 g, 24.35±2.24 mg AAE/g and 3.61±0.23 mg AAE/100 g, respectively compared to the other vegetable spices. On the other hand, vitamin C content was highest in *Allium sativum* L followed by red *Allium cepa* L registering values of 455.0±2.12 and 443.4±2.50 mg AAE/100 g, respectively. The reducing power (in mg AAE/g) of the vegetable spices was highest in green bell pepper (*Capsicum annum L*.) with the value of 17.11±1.549 followed by red *Allium cepa L*. (9.519±0.860) and *Allium sativum L*. (5.922±0.778), respectively. Total tannins content, in mg TAE/g, was highest in *Allium sativum* L, which registered the value of 159.56±4.84 followed by *Zingiber officinale* (91.53±0.33), bell pepper (79.94±0.21) and *Allium cepa* L (49.36±1.98). Furthermore, phytic acid and oxalic acid contents were highest in *Zingiber officinale* registering values of 5.504±0.822 mg/kg and 37.25±2.83 mg/g, respectively. Red *Allium cepa L*. was found to contain 20.53±0.916 mg/g oxalic acid but had the lowest phytic acid content registering the value of 2.057±0.095 mg/kg. It can be concluded that the high phytochemical composition in the four vegetable spices, with low antinutrients like phytic and oxalic acids, can play an important role in improving human nutrition and health of consumers.

Key words: Phytochemicals, Vegetable spices, Antioxidant capacity, Phenolic, Phytic acid, reducing power

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INTRODUCTION

The significance of natural antioxidants and their effectiveness in human disease prevention and cure is tremendously growing [1]. Antioxidants just like phytochemicals improve human immunity by neutralizing free radicals interactively and synergistically. Synthetic antioxidants like butylhydroxyanisole (BHA) and butylhydroxytoluene (BHT) are reported to be toxic and carcinogenic, resulting in increased research in natural antioxidants [2]. Plants are reported as excellent sources of anti-oxidative compounds which control reactive oxygen species (ROS) for plant survival [3]. Reactive oxygen species either suppress enzyme activity or destroy body cellular components resulting in the initiation of the development of diseases like cancer, liver injury, diabetes and cardiovascular diseases [4]. Plants have free radical scavenging molecules like vitamins, phenolic acids, flavonoids, tannins, alkaloids and other secondary plant metabolites, which are rich in antioxidant capacity [5]. In normal human metabolic pathways, radicals are produced during oxidation reactions and these reactions increase under environmental stress and pathogenic attack. When left uncontrolled, the free radicals damage the cells in living organisms leading to the development of several diseases like cancer and coronary heart diseases [6]. It has been shown, epidemiologically, that an intake of plant-based diets, high in vegetables and fruits, either delays or reduces the risks of chronic health conditions like cancer, neurodegenerative and cardiovascular diseases [7]. This is because plants and their fruits have high concentrations of antioxidants, which are responsible for the prevention of diseases [7].

There is growing research interests in the use of vegetables/plants as herbs and spices for food preservation and medicinal purposes [1]. Spices and herbs are processed from roots, leaves, fruits or the whole plant and used to season food to enhance flavor and aroma [8]. Spices are either whole, ground or as essential oils and oleoresins that are extracted to formulate essences and liquid soluble spices [8]. Spices, like ginger, are rich in chain-breaking antioxidants which inhibit the oxidation process by reacting with fat free radicals/peroxyl radicals [8]. Garlic, ginger and other vegetables like onions and green bell pepper have been reported to have pharmaceutical properties [8, 9].

Ginger (*Zingiber officinale*) belongs to the family *Zingiberacea*. *Zingiber officinale* was initially grown in China and then in India, Southeast Asia, West Africa and Caribbean [10]. *Zingiber officinale* rhizomes are used for cooking as spices in various foods and beverages and for medicinal purposes [11]. Ginger is reported to cure nausea, sprains, vomiting, infectious diseases and assists in digestion processes [12]. Gingerol is the most active constituent in fresh ginger whose chemical structure is similar to that of polyphenols [13]. Therefore, the pharmacological and biological activities from ginger is attributed to the presence of polyphenols which have antioxidant activities [14].

Garlic (*Allium sativum L*) and red onion (*Allium cepa L.*) belong to the family *Alliaceae* / *Liliaceae* [15] and are significant ingredients in the diet of many world populations [3]. Garlic and onions are used as spices in cooking food and have many medicinal purposes as herbs. Garlic has been a significant ingredient in ethno Chinese medicine

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[3, 9]. The main bioactive chemical in garlic is *allicin*, which is used as a protective agent against insects and fungi when damaged [16]. There are four commercially available garlic supplements, which include dehydrated powder, oil, oil macerate and aged extracts [17].

Onions, red onions inclusive, are described as native to Eurasia and have lately been grown all over the world [5]. *Allium spp* have been reported to possess antibacterial and antifungal properties with high antioxidant capacity from sulphur, flavonoids quercetin, kaempferol, myricetin, catechin, anthocyanins, and other phenolics [9, 18]. Other researchers have previously reported that consumption of onions is associated with retardation in the development of cancer and is used in the treatment of diseases like cataract and type II diabetes [9].

Bell pepper (*Capsicum annum* L.) is native to Central and South America. Other researchers have reported that fresh green bell pepper contains 106.4±2.0 mg/100 g of vitamin C on fresh weight basis, from methanol extracts, and has high concentration of phenolics of 48.4±0.6 mg/100g resulting in high antioxidant capacity [19]. Similarly, other authors have reported that green bell pepper has high chlorophyll and carotenoid contents, which have high antioxidant capacity [20]. Furthermore, it has also been reported that bell peppers have high concentration of flavonoids. Flavonoids have biochemical and pharmacological characteristics like antioxidation, anti-inflammation, antiallergy and anticancer [21]. Therefore, consumption of green bell peppers is associated with retardation of various diseases resulting from radical oxidation [22].

In Malawi, just like in many other countries, the consumption of *Zingiber officinale*, *Allium spp*, *Capsicum spp,* (green bell pepper) vegetables as spices and condiments is increasing and are important ingredients in the preparation of different foods/dishes. However, from the current literature, it is evident that limited research has been conducted on the phytochemical and antioxidant activities of *Zingiber officinale*, *Allium spp* and *Capsicum spp* consumed in Malawi. Against this background, the purpose of this study was to determine the total phenolic content and antioxidant capacity of ginger (*Zingiber officinale*), red onion (*Allium cepa* L.), garlic (*Allium sativa* L.) and green bell pepper (*Capsicum annum* L.) consumed in Malawi.

MATERIALS AND METHODS

Sample collection and preparation

Four fresh vegetables: *Allium sativum* L., *Allium cepa* L., *Zingiber officinale* and green bell pepper (*Capsicum annum* L.,) (Figure 1) were purchased from the local market in Mitundu, Lilongwe district, central Malawi. The samples were purposely selected based on their freshness.

Adequate samples, about 50 g, of the fresh vegetable spices were sliced using a kitchen knife and a fraction of the samples was used for dry matter composition determination. The other fraction was frozen for further analyses of the phytochemical composition of the spices.

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***Allium cepa* L.** ***Capsicum annum* L.** ***Zingiber officinale* root** ***Allium sativum* L.**

Figure 1: Samples of vegetable spices

Preparation of extracts

The phytochemical extraction from vegetable spices was done by following the method described by Chaves *et al.* [23] with minor modifications. The samples were cut into small pieces, macerated in a food blender and extracted using 80% methanol in a 1:4 w/v ratio, for 24 hr with continuous shaking. The extracts were filtered using a Whatman no 1 filter paper and the filtrate/ extracts were concentrated by evaporating excess solvent using a rotary evaporator at 40 ºC. The extracts were diluted in 1:4 w/v ratio in 80% methanolic solution to obtain absorbance readings that fall within the standard curve concentration range of 0.0-200.0 mg gallic acid /ml.

Determination of dry matter (DM) composition

Dry matter content was determined by drying the samples in a laboratory oven at 105 ºC for 5 hrs. Porcelain crucibles were thoroughly washed, dried in the oven, cooled in a desiccator and weighed. Samples (2.5 g) were weighed into the crucibles and dried to constant weight. The DM content, in percentage, was calculated as the fraction of the final constant weight over the original fresh sample weight multiplied by 100 [24].

Determination of total phenolic content (TPC)

The total phenolic content was determined by using the Folin-Ciocalteau colorimetric method presented by Singletone and Rossi [25]. The sample extract (1 ml) was mixed with 2.5 ml of Folin-Ciocalteau reagent (1:10 v/v) and left for 5 mins followed by the addition of 2.5 ml of 7.5% $NaHCO_3$ in test tubes. Standard gallic acid samples of 0, 1, 2, 3, 4, 5, 6 mg were prepared from a stock solution of 1 mg/ml by pipetting 0-6 ml into six different test tubes. Similarly 2.5 ml of Folin-Ciocalteau reagent and 2.5 ml of $NaHCO_3$ were added in the six standard test tubes. The samples were incubated for 20 min at room temperature for color development. The absorbance was measured at 765 nm using spectrophotometer. Total phenolic content (TPC), expressed as mg of gallic acid equivalent (GAE) per 100 g of fresh weight sample, was calculated from the standard gallic acid curve using linear equation Y=0.739x (Figure 2). Total phenolic content was finally calculated as follows: $TPC\ (\text{GAE}g^{-100}) = \left(\frac{C\ x\ v}{m}\right) x100$

where C= concentration of standard solution of gallic acid

V= total dilution volume, m= mass of sample in grams

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Determination of total tannin composition

Total tannin content was determined by the spectrophotometric method described by Shrin and Prakash [32] with minor modifications. The 80% methanolic extract (1 ml) was mixed with 0.5 ml of Folin-Denis solution (1:10 v/v) and 0.5 ml of concentrated Na_2CO_3 and the solution was diluted to 10 ml. A stock solution of 1 mg/ml tannic acid was prepared and standard solutions of 0-8 mg were prepared. The standard solutions were similarly treated as the samples and absorbance was measured at 760 nm after 30 min of color development using UV spectrophotometer. The total tannic acid content, as mg TAE/g, was calculated from standard tannic for the curve using linear equation Y=0.1780x.

Determination of total antioxidant activity

The total antioxidant activity was determined by using a phosphomolybdenum method with minor modifications [26]. The basic principle of the assay is based on the reduction of Mo (VI) to Mo (V) by the sample extracts with a subsequent formation of a green phosphate complex in an acidic condition. The extract (1 ml) was pipetted into the test tubes and 1 ml of the reagents (0.6M sulphuric acid, 28 Mm sodium phosphate, 4 mM ammonium molybdate) were added and the tubes were incubated while capped in a water bath at 95 ^oC for 90 minutes. Standard ascorbic acid samples of 0-6 mg concentrations, prepared from a 1 mg/ml stock solution, were similarly treated. After cooling, absorbance of the samples and standards were measured at 695 nm using UV spectrophotometer against the blank. A standard calibration curve of ascorbic acid was plotted and total antioxidant activity was calculated as ascorbic acid equivalent (AAE) in mg per g fresh weight (AAE/g FW).

Reducing power assay

The reducing capacity was determined by following Oyaizu [27] method with minor modifications. The sample methanolic extracts (2.0 ml), 1.0 ml of 0.2 M sodium phosphate buffer (pH 6.6) and 1% w/v potassium ferricyanide were pipetted into a test tube. The mixture was incubated at 50 ^oC for 20 min and 2.5 ml of 10% w/v trichloroacetic acid, after cooling, was added to stop the reaction. The mixture was centrifuged at 3000 rpm for 10 min where necessary. The supernatant solution (1.0 ml), distilled water (1.0 ml), and 1.0 ml of 0.1% of freshly prepared ferric chloride solution were pipetted into the test tube and were mixed to develop the color. Standard ascorbic acids (0-6.0 mg) were prepared from 1.0 mg/ml stock solution and were similarly treated as the sample extracts. The absorbance of the samples, after 10 min of color development, was measured at 700 nm using UV-spectrophotometer. A standard calibration curve of ascorbic acid was plotted. The high absorbance of the reaction mixtures indicated the high/increased reducing power of the samples with reference to that of the standard ascorbic acid.

Determination of titratable acidity

Titratable acidity in the vegetable spices was determined by following the method described by Abiola *et al.* [28] with minor modifications. Ten (10) g of the sample was macerated in 100 ml of distilled water and was continuously stirred for 30 mins. The contents were filtered and titrated against 0.1 M NaOH using two drops of

phenolphthalein as an indicator. The results were calculated as mg/100 g using the following equation:

$$TA\left(\frac{mg}{100g}\right) = \frac{Vol.ml_{NaOH}x\ 0.1M_{NaOH}x\ 0.00605\ x100}{mass\ of\ sample\ in\ g}$$

Determination of vitamin C content

The sample (5 g) was blended in 20 ml of oxalic and trichloroacetic acid solutions using a food homogenizer to extract vitamin C as described in Food Analysis Manual by Zvaigzne *et al.* [29] with minor modifications. The mixture was filtered and the filtrate was transferred into a 100 ml volumetric flask. The volume was adjusted to the 100 ml mark with 5% oxalic acid. The solution (5 ml) was pipetted into a conical flask and was titrated with 2-6 dichlorophenol indophenol dye to a faint rose pink color (V_1). Five (5) ml of 1 mg/ml standard ascorbic acid solution was pipetted into a conical flask, mixed with 10 ml of 5% oxalic acid and titrated to faint rose pink color against 2-6 dichlorophenol indophenol (V_2). Vitamin C content, as ascorbic acid in mg/100g, in the test samples was calculated as follows:

$$Vitamin\ C\ (mg100g^{-1}) = \frac{100xV_1x100x100}{V_2x5x5}$$

Determination of phytic acid content

Davis and Reld method as modified by Abulude [30] was used in determination of phytic acid. A dried sample (2.5 g) was extracted in 100 ml of 2 % HCl in 250 ml conical flask for 3 hours. The filtrate was obtained from the mixture using Whatman filter paper and 25 ml of the filtrate was added to 107 ml of distilled water, 10 ml of 3 % ammonium thiocyanate (NHSCH). The mixture was titrated against standard $FeCl_3$ containing 1.95 mg Fe/ml to brownish – yellow color that persisted for 5 min. Phytate content was calculated as follows:

Phytate phosphorus = iron equivalent x 1.95 mg of titre

Phytate = phytate phosphorus x 3.65 g

Determination of oxalate content

Oxalate content in the samples was determined by the method described by Chinma and Igyor [31] method with minor modifications. Oxalate was extracted from 2.5 g of the samples in 75 ml of 3 M H_2SO_4 for 3 hr with continuous shaking. The mixture was filtered and 25 ml of the filtrate was titrated against 0.05 M KMnO4 solution to a faint pink color that lasted for 30 seconds. The oxalate content was calculated basing on the assumption that 1 ml of 0.05 M $KMnO_4$ is equivalent to 2.2 mg oxalate.

Statistical Analysis

Chemical analyses on the samples were done in triplicate in the laboratory. Statistical analysis was performed in statistical package for social sciences (SPSS version 20). The statistical analysis involved numerical summaries in form of the mean and error bars of the nutrient content by the spices. This was followed by the one-way analysis of variance of each nutrient by the spices to test for significant difference of the nutrient between spices and significance was accepted at $P \leq 0.05$ level.

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RESULTS AND DISCUSSION

Phytochemical and antioxidant composition of the vegetable spices

The phytochemical composition of the four vegetable spices is presented in Table 1.

Total phenolic composition

Total phenolic content, as mg GAE/100g, ranged from 72.32±0.394 to 326.5±0.394 mg/100g for red onions and ginger respectively. The study's findings revealed that green bell pepper (*capsicum annum L.*) had lower TPC (124.9±0.197) compared to red onions (169.7±0.00) at 8.04±0.23% and 13.44±0.64% DM content but higher values compared to 72.72±0.394 for garlic (*Allium sativum* L) at 37.83±0.40% DM content. The total phenolic content value for *Allium cepa* L (red onions) obtained from this study was lower compared to the value of 389.5±4.9 mg/g for onion reported in India [13] and 5343±1.72 mg GAE/100g reported in Malaysia [3]. However, Lenková *et al.* [32], reported total phenolic content of 131.3±2.97 mg GAE/100 g for red *Allium cepa* L., which was lower than the value obtained from this study. Other researchers on a work conducted in Japan reported lower total phenolic content of 48.4±0.6 mg GAE/100g FW for green bell pepper compared to the value from this study [19]. Shrin and Jamuna [33] in India reported that ginger rhizomes contain 780±5 mg GAE/100 g TPC which was higher compared to the value obtained in this study. The TPC value for *Allium sativum* L. obtained in this study was comparable to the values of 105.1±1.81 and 87.1±0.82 for *Allium sativa* L. and wild *Allium sativum* L., respectively reported in work conducted in Slovak Republic [32]. Total phenolic compounds are mainly responsible for the antioxidant activity of vegetables, fruits and other plant-based foods. Plants derive their antioxidant activity from their potential to reduce electrons in the body system which behave like hydrogen or electron donors [34]. The high TPC values obtained in this study suggest that red onions, garlic, green bell pepper and ginger roots /rhizomes have high potentials to reduce electrons in human bodies.

Tannin composition of the vegetable spices

The tannin content, in mg TAE/g FW sample, varied significantly ($P \leq 0.05$) from 49.36±1.976 to 159.6±4.840 with red *Allium sativum* L registering the lowest and *Allium sativum* L the highest value. The study findings revealed that *Allium cepa* L. spices contained less tannins compared to *Allium sativum* L., *Zingiber officinale* rhizomes and green bell pepper. Other authors have previously reported that *Zingiber officinale* contains 11.2±0.5 mg/g tannins, which was lower compared to the value obtained in this study [35]. Low values of tannins of 0.7±0.00, 35.4±0.00 and 17.7±0.2 mg TAE /g for garlic (*Allium sativum* L), ginger (*Zingiber officinale)* and green bell pepper (*Capsicum annum* L.), respectively, have been reported in research conducted in Nigeria [36]. The variations in the tannin content among the values obtained in this study and the other studies done by researchers in different countries could be attributed to several factors such as differences in analytical methods used and the stage of maturity of the spices at the time of harvesting. Tannins have been reported to possess antiseptic properties [36] and, therefore, the consumption of these vegetable spices could improve the human body immune system.

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Antioxidant composition of the vegetable spices

The antioxidant composition is presented in Table 2. Antioxidant compounds being phytochemicals are responsible for the retardation of the development of chronic degenerative illnesses like cancer, cardiovascular diseases and diabetes [37]. Antioxidant capacity, in mg AAE/100 g, was highest in *Zingiber officinale* rhizomes (21.78±0.21) and the lowest value of 5.52±0.02 was obtained in *Capsicum annum L.* (green bell pepper). Garlic bulb had higher antioxidant capacity content (18.12±0.04) compared to the value of 9.34±0.02 obtained in red onions. Some researchers in India reported antioxidant capacity in garlic (*Allium sativum* L.) as 634.00±39.00 mgAAE/100 g, which was higher compared to the value of 18.12±0.04 mgAAE/100 g obtained in this study [38]. Other authors previously reported that *Allium cepa* L. bulb contains 12.94±1.94 mgAAE antioxidant in every 100 g plant material, which was higher compared to the value of 9.34±0.02 mgAAE/100 g obtained in this study [39].

Vitamin C composition in the vegetable spices

Vitamin C delays the development of chronic degenerative diseases like cancer by either preventing the formation of N-nitroso in the stomach or by increasing the body's immune system [40]. Red onions and garlic bulb had high concentrations of vitamin C of 443.4±2.80 mg AAE/100 g and 455.0±2.12 mg AAE/100 g compared to *Capsicum annum L*. (green bell pepper) (6.31±0.30) and *Zingiber officinale* (3.606±0.401 mg AAE/100 g). The findings from this present study have shown that *Allium spp* has higher vitamin C content than green bell pepper and *Zingiber officinale*. The vitamin C contents of 443.4±2.80 mg AAE/100 g and 455.0±2.12 mg AAE/100 g for *Allium cepa* L. (red onion) and *Allium sativum* L. (ginger rhizome) obtained in this study were higher compared to the values of 229.098±0.92 mg AAE/100 g and 191.89±0.93 mg AAE/100 g reported in a similar study in Nigeria [41]. On the other hand, the vitamin C content of 6.31±0.30 mg AAE/100 g for green bell pepper (*Capsicum annum* L.) obtained in this study was lower compared to the value of 115.5±2.2 mg AAE/100 g reported in a study done in Japan [19].

Ferric reducing power of the vegetable spices`

Results on the reducing power of the four vegetable spices are presented in Table 2. The results show that the vegetable extracts had high degree of electron-donating capacity with reference to the increasing sample extract concentration. Ginger (*Zingiber officinale*) 80% methanolic extracts had the highest ($P<0.05$) reducing power followed by green bell pepper (*Capsicum annum* L.), red onions (*Allium cepa* L.) and garlic bulb (*Allium sativum* L.) extracts at all concentrations. The reducing power of bioactive compounds is correlated to their antioxidant activity [41]. Reducing power, in mg AAE/g, was highest (24.35±2.239) in *Zingiber officinale* and lowest (5.922±0.778) in garlic bulb. Red onions and *Capsicum annum L.* (green bell pepper) had 9.593±0.860 and 17.11±1.549 AAE/g, respectively. The reducing power capacity of 9.336±0.018 mg AAE/100 g for red onion (*Allium cepa* L.) obtained in this study was higher compared to the value of 5.37±1.185 mg AAE/100 g reported in other work done in Nigeria [39].

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Chemical composition and anti-nutrient content

Chemical composition and anti-nutrient content of the vegetable spices are presented in Table 3. Titratable acidity in fruits and vegetables denotes either the stage of maturity or whether the fruits and vegetables are ripe. Titratable acidity defines the number of organic acids present in fruits and vegetables, which increases during maturity and ripening processes [42]. Total acidity as titratable acidity (TA) composition, in mg acetic acid/100 g, was highest in *Zingiber officinale* (787.5±21.60) and lowest in green *Capsicum annum L*. (35.75±1.00), respectively. *Allium sativum L*. had high TA content of 300.00±0.00 compared to 112.5±4.00 for red *Allium cepa L*. Ukoha *et al.* [40] reported that red onion, white onion and garlic bulb contain 90.075, 72.06 and 63.053 mg acetic acid/100 g, respectively, as TA, which were lower compared to the values obtained in this study. The TA value in garlic of 300.00±0.00 mg acetic acid/100 g was lower compared to an average value of 1070.566±2.363 mg acetic acid/100 g for four ginger varieties [43]. Other researchers reported a higher TA content of 161.328 in yellow bell pepper compared to the value obtained in this study for green bell pepper [44]. However, in Spain other researchers reported TA value of 33.086±9.453 mg acetic acid/100 g for green bell pepper, which was comparably similar to 35.75.±1.00 mg acetic acid/100 g obtained from this study [42]. The variations in the TA compositions between results obtained in this study and previous studies could be attributed to climatic conditions, soil nutrients and stage of maturity of the vegetable spices at the time of harvesting.

Phytic acid is an inositol hexaphosphate that binds calcium and iron making them biologically unavailable to humans [45]. Consumption of 4-9 mg/100g of phytic acid may end up in the decrease of 4-5 fold of iron absorption in humans [46]. The general intake of phytic acid in humans, from vegetarian food, has been recommended at 2000-2600 mg daily and in emerging world, rural people are advised to consume 150-1400 mg of phytic acid per day from a mixed diet [47].

Phytic acid concentration varied from 2.057±0.095 to 5.504±0.822 mg/kg with *Zingiber officinale* registering the highest and red *Allium cepa L*. the lowest values. Green bell pepper (*Capsicum annum L*.) (3.322±0.082 mg/kg) had higher phytic acid content than *Allium sativum L* (2.705±0.028 mg/kg). The phytate composition from this study has revealed that *Allium spp* have higher phytic acid content than *Zingiber officinale* and green bell pepper (*Capsicum annum L*.). However, phytic acid compositions for *Allium spp*, green bell pepper (*Capsicum annum L*), and *Zingiber officinale* obtained in this study were below 9 mg/100 g.

Oxalic acid content in *Zingiber officinale* (ginger) rhizome was 37.25±2.829 mg/g, which was higher compared to the value of 7.773±0.916 mg/g which was registered in *Capsicum annum L.* (green bell pepper). On the other hand, *Allium cepa L.* (red onion) had 20.53±0.916 mg/g which was high compared to the value of 8.213±0.672 mg/g, which was obtained in *Allium sativum L.* (garlic bulb).

It has been reported that oxalic acid consumption of 2-5 g/100 g is toxic because it culminates in the reduction of bioavailable minerals such as calcium [48]. Therefore, this study has shown that consumption of *Allium spp*, green bell pepper (*Capsicum*

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annum L.) and *Zingiber offinale* would not result in reduction of calcium availability to humans. Furthermore, proper processing of vegetable spices such as cooking reduces oxalic acid concentration [48].

CONCLUSION

The results from this study have revealed that red onion (*Allium cepa L.*), garlic (*Allium sativum L.*), ginger (*Zingiber officinale*) and green bell pepper (*Capsicum annum L.*) are excellent sources of antioxidants as reflected by the higher levels contained. The consumption of these vegetable spices is highly recommended as they can help improve human nutrition and health through prevention of diseases such as cancers through their free radical scavenging abilities.

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Table 1: Phytochemical composition of the vegetable spices

Vegetable	DM%	Total Phenolic (mgGAE/100g)	Tannins (mgTAE/g)
Red Onions	13.44±0.64^{c}	169.74±0.000^{b}	49.36±1.976^{da}
Garlic bulb	37.83±0.40^{a}	72.72±0.394^{d}	159.60±4.840^{a}
Green Bell pepper (*Capsicum annum* L.)	8.04±0.23^{d}	124.90±0.197^{c}	79.94±0.208^{c}
Ginger rhizome (*Zingiber officinale*)	15.98±0.14^{b}	326.5±0.394^{a}	91.53±0.329^{b}
F-test (P-value)	3226.531(<0.001)	137448.111(<0.001)	315.542 (<0.001)

Data represent mean (±SE) of three separate measurements. Different letters in the same column represent significantly different values (P≤0.05)

Table 2: Antioxidant composition of the vegetable spices

Vegetable spice	DM %	Antioxidant Capacity (mgAAE/100g)	Vitamin C (mgAAE/100g)	Reducing Power (mgAAE/g)
Red onions	13.44±0.64^{ca}	9.34±0.02^{ca}	443.4±2.50^{ba}	9.519±0.860^{ca}
Gallic	37.83±0.40^{ab}	18.12±0.04^{b}	455.0±2.12^{ab}	5.922±0.778^{db}
Bell pepper (*C. annum* L.)	8.04±0.23^{dc}	5.52±0.02^{dc}	6.31±0.30^{c}	17.11±1.549^{bc}
Ginger rhizome	15.98±0.14^{bd}	21.78±0.21^{ad}	3.61±0.23^{d}	24.35±2.239^{ad}
F test (P-value)	3226.531(<0.001)	214941.43 (< 0.001)	21228.609 (<0.001)	30.743 (<0.001)

Data represent mean (±SE) of three separate measurements. Different letters in the same column represent significantly different values (P≤0.05)

Table 3: Chemical composition and anti-nutrient content of the vegetable spices

Vegetable	Titratable Acidity (mg acetic acid /100g)	Phytic acid (mg/kg)	Oxalate (mg/g)
Red Onions (*Allium cepa* L.)	112.5±4.00^{c}	2.057±0.095^{c}	20.53±0.916^{b}
Garlic bulb (*Allium sativum* L.)	300.0±0.00^{b}	2.705±0.028^{d}	8.213±0.672^{c}
Green Bell pepper (*Capsicum annum* L.)	35.75.±1.00^{d}	3.322±0.082^{b}	7.773±0.916^{d}
Ginger rhizome (*Zingiber officinale*)	787.5±21.60^{a}	5.504±0.822^{a}	37.25±2.829^{a}
F-test (p-value)	935.85 (<0.001)	38.848 (<0.001)	227.675 (<0.001)

Data represent mean (±SE) of three separate measurements. Different letters in the same column represent significantly different values (P≤0.05)

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