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Original Research

An assessment of bioactive compounds and antioxidants in some tropical legumes, seeds, fruits and spices

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ABSTRACT:

Objective:

The main objective of this research was to assess bioactive compounds, antioxidant potential and mineral concentration of commonly consumed foods as well as underutilized ones for improved health and food security.

Methods:

Twelve food samples were assessed for minerals, flavonoids, IP_6, total polyphenols and antioxidant activity. IP_6 was determined by anion exchange chromatography while flavonoids, polyophenols, minerals and antioxidant activity were determined by standard methods.

Results:

The highest concentrations of IP_6 were recorded in legumes and corn while appreciable levels were also found in golden apple and sorrel samples. The highest concentrations of flavonoids and total polyphenols were found in non-leguminaceaous samples. Pimento and ginger samples recorded highest antioxidant activity ($p<0.05$) with values comparable to the standard ascorbic acid while pumpkin seeds and onion samples recorded lowest antioxidant activities. Mineral concentrations varied with the samples of pimento, golden apple and sorrel having highest calcium concentrations. Sorrel, ginger and pimento recorded highest iron concentrations, while zinc levels were as highest in both hulled and unhulled pumpkin seed samples. Okra samples recorded the highest copper concentrations.

Conclusion:

Food samples analysed are rich in minerals, bioactive compounds and antioxidants hence their increased exploitation for nutraceutical and nutritional benefits are advocated. Data from this study argues well for increased production and consumption of rarely consumed pumpkin and jackfruit seeds in light of their nutritional profile and antioxidant activity. Most samples assessed are valuable in supplementing nutrient-poor diets.

Keywords:

Antioxidants, bioactive compounds, spices, legumes, seeds

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INTRODUCTION

In light of concerns regarding food security and quality, there is great interest in ascertaining the nutritional benefits of foods commonly consumed throughout the tropics. Functional food researchers generally agree that in addition to macronutrients, it is also important to assess minerals as well as levels of bioactive compounds that may contribute to the overall quality and health benefits of foods consumed by a wide cross section of people in different geographical locations. To that effect, assessing the antioxidant activities of food samples is also important as it indicates their ability to counteract the effects of free radicals. Free radicals are independently existing atoms or molecules that have one or more unpaired electrons (Williams *et al*., 2006). They are generated daily in living systems arising from the metabolic processes that form a part of normal aerobic metabolism (Saha *et al*., 2008). The increased incidences of many diseases including cell tumours, type II diabetes mellitus and coronary heart diseases are attributed to the effects of highly active free radicals (Marinova *et al*., 2005; Olajire *et al*., 2011).

Throughout the Caribbean, there are many food crops which are believed to possess therapeutic properties. These beliefs are largely based on tradition and have resulted in increased interest in the area of ethnopharmacology. It is now theorized that traditional medicine has immense value and the therapeutic properties of foods may be due in part to the presence of bioactive compounds (Sreeramulu *et al*., 2013). The development of an industry from this knowledge is considered an important contributor to economic growth in the tropics (Dilworth *et al*., 2013). Some of the foods of interest are spices and condiments including pimento, ginger, onions, okra and sorrel that are reported to possess important health benefits (Rubio *et al*., 2013; Kaefer and Milner, 2008; Tsai *et al*., 2014; Pérez-Gregorio *et al*., 2014). Other foods of interest include legumes and seeds including corn, pumpkin seeds, jackfruit seeds, pigeon peas, broad beans, kidney beans as well as golden apple (Hanson *et al*., 2014; Swami *et al*., 2012; Kalogeropoulos *et al*., 2013; Islam *et al*., 2013). Some of these foods are commonly consumed and are reported to have a myriad of health benefits while others are not commonly consumed but are easily available and also have health promoting properties which should be explored. The health benefits and reported underutilization of some samples along with the potential economic benefits of their incorporation into mainstream consumption prompted research interest in the food samples selected.

Since antioxidants are shown to significantly delay or prevent the oxidation of easily oxidizable substances, there is now an increased interest in the role of natural antioxidants from different food sources. Inositol hexakisphosphate or IP_6 (also known as phytic acid or phytate when in salt form), is also thought to play a role in antioxidant activity of cells. IP_6 is the principal storage form of phosphorus in many plant tissues, especially bran and seeds, where it exhibits antioxidant properties via chelation of hydroxyl radicals (Graf and Eaton, 1990; Johnson *et al*., 2000). IP_6 concentrations in most of the food samples previously mentioned are not known and therefore warrant investigation.

Minerals are an important contributor to the nutritional value of foods as they play significant roles in many essential metabolic processes. They are important in cognitive development, function as enzyme cofactors, and play important roles in structural and epithelial integrity among numerous other functions. Reduced levels and bioavailability of minerals is thought to be a major health challenge in developing countries. There is however, a paucity of information regarding overall antioxidant properties and health benefits of many commonly eaten foods. In light of the current boom in the nutraceutical industry, it is important to assess their antioxidant properties since this will positively contribute to their marketability. This will also enhance the commercial viability of the region since specific foods and their value added products can be marketed for economic development.

This study was geared at assessing the nutritional value of foods delivered to the market for consumption by the local population, since the average consumer purchases food from the market and not directly from the farm. Checks were done to ensure that all samples were delivered to the market directly from the farm within three days or less since older samples may have reduced bioactive compounds and antioxidant activity owing to improper storage. This research was aimed at ascertaining antioxidant properties, bioactive compounds and mineral concentration of commonly consumed foods while assessing some other uncommon foods for incorporation into mainstream consumption or for use as nutraceuticals.

METHODOLOGY

MATERIALS:

Chemicals and Reagents were purchased from Sigma-Aldrich Co. (MO, USA).

Samples

A wide variety of commonly eaten foods including tuber crops, fruits, vegetables, condiments and spices were selected for analyses. They were as follows: Kidney bean (*Phaseolus vulgaris*), Butter bean (*Phaseolus lunatus*), Pigeon peas (*Cajanus cajan)*, Okra (*Hibiscus esculentus*), golden apple (*Spondias dulcis*), Jackfruit (*Artocarpus heterophyllus*), Sorrel (*Hibiscus sabdariffa*), Onion (*Allium cepa*), Ginger (*Zingiber officinale*), Pimento (*Pimenta dioica*) and Corn (*Zea mays*). Samples were collected from the main market in the city of Kingston, Jamaica, then taken to the laboratory, washed and oven dried to a constant weight. Samples were then crushed in a General electric motor and industrial system laboratory mill with the mesh size of 0.2 mm and stored frozen for further use.

METHODS

Determination of Minerals

The minerals calcium, copper, zinc and iron were determined by standard methods (AOAC, 2005). A specified amount of ground sample was completely ashed followed by acid digestion and dilution with deionized water. Samples were read using a Unicam 939 atomic absorption spectrophotometer equipped with background correction and cathode lamps. Accuracy of the analytical method was confirmed through a series of certified analyses on reference materials. Appropriate spikes were added to specific samples for recovery determinations.

Total phenol

Total phenol levels were determined by a modification of the Folin-Ciocalteu assay method as described by Sun *et al*., (2006) and Prasad *et al*., (2010). Following methanol extraction, 0.5 mL of Folin reagent was added to samples and then Na_2CO_3 was also added. Samples were vortexed and incubated, diluted with deionized water, centrifuged and absorbance read at 725 nm. A standard curve for gallic acid was done based on a similar procedure as outlined above. Extrapolations for total polyphenol concentration were then carried out from the curve and values given as mean ± SD mg gallic acid equivalents/mL.

DPPH radical scavenging activity:

DPPH radical scavenging activity was determined by slight modifications of methods outlined by Matkowski *et al*., (2008), Veeru *et al*., (2009) and Hasan *et al*., (2006). Plant extracts were double extracted with methanol for 24 hours then rotor evaporated to dryness and the DPPH assay was carried out to determine the concentration of each extract required to cause 50% inhibition. Samples were read at 517 nm against a pure methanol blank in duplicates and the percentage inhibition was determined according to the equation below. IC_{50} values were determined from the graph of the percentage inhibition against extract concentration.

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

Flavonoids

Total flavonoid content was assessed by the aluminum chloride colorimetric assay as previously reported (Marinova *et al*., 2005). An aliquot of the methanolic extract was centrifugated and added to deionized water, sodium nitrateand aluminium chloride. Sodium hydroxide was then added and the volume made up to 10 mL with deionized water. Solutions were mixed thoroughly and the absorbance was read at 510 nm against a reagent blank. Total flavonoid content was expressed as catechin equivalents (CE)/100 g dry mass.

IP_6

Assessment of IP_6 was done by a method previously described by Siddhuraju and Becker (2001). It involved a colorimetric method in addition to ion exchange purification. Duplicate ground samples were stirred with HCl at room temperature followed by centrifugation. Aliquots were diluted with distilled water and the pH was adjusted to 6. The diluted extract was quantitatively transferred to a column with anioinic exchange resin. Inorganic phosphate was eluted with 0.1 M NaCl while IP_6 was eluted with 1M NaCl and collected. The purified extract, standards and water were added to the modified Wade reagent. It was vortexed for 5 seconds and the absorbance was read immediately at 500 nm.

Table 1.0: IP6, Flavoniods and total phenolics in legumes, seeds and spices

Samples	IP6 (µg/g)	Flavonoids (CE/100 mg)	Total phenolics (mg/100 g)
kidney bean	2750.20 ± 9.02^{a}	145.21 ± 5.03^{d}	16.38 ± 1.40^{a}
broad bean	1466.67 ± 15.15^{ab}	90.61 ± 20.21^{d}	5.61 ± 1.79^{d}
Pigeon peas	2483.67 ± 13.21^{a}	119.91 ± 2.09^{d}	11.63 ± 0.72^{a}
Jackfruit seeds	462.50 ± 62.51^{c}	105.65 ± 34.07^{d}	22.38 ± 1.73^{ab}
Pimento	1183.33 ± 16.66^{bc}	2685.68 ± 15.30^{a}	2.87 ± 0.17d
Pumpkin seeds (h)	2558.21 ± 18.67^{a}	60.93 ± 3.21^{d}	8.23 ± 3.41^{d}
Pumpkin seeds (u)	2554.67 ± 20.59^{a}	95.64 ± 24.55^{d}	21.32 ± 1.57^{ab}
Corn	2025.52 ± 75.83^{a}	50.11 ± 2.54^{d}	80.21 ± 2.14^{c}
Okra	700.21 ± 17.21^{c}	595.91 ± 85.53^{c}	27.95 ± 2.67^{b}
Sorrel	1520.83 ± 23.52^{d}	1665.64 ± 18.81^{b}	5.30 ± 1.30^{b}
Onion	941.66 ± 16.67^{bc}	85.86 ± 5.34^{d}	36.72 ± 1.29^{b}
Ginger	441.67 ± 25.25^{c}	470.86 ± 50.34^{c}	87.99 ± 4.05^{c}
Golden apple	1945.83 ± 20.83^{ab}	325.66 ± 35.35^{c}	28.25 ± 1.70^{b}

Values in the same column with different letter subscripts are significantly different $p<0.05$. Values are expressed as mean ± SEM.

Statistical analyses

Data were finally expressed as means ± SEM. Analysis of variance was used to ascertain differences among different samples by using the Statistical package for the social sciences software version 16.0. Differences among means were assessed by the Duncan's multiple range test where significance was confirmed by a cutoff p value <0.05, (Sokal and Rohlf, 1969).

RESULTS AND DISCUSSION

IP_6

Since IP_6 is found mostly in the aleurone layer of cereals and grains we would expect highest levels in grain and seed samples. This was generally observed in the samples of kidney beans (2750.20 ± 9.02 µg/g), pigeon peas (2483.67 ± 13.21 µg/g), broad bean (1466.67 ± 15.15 µg/g), pumpkin seeds (2558.21 ± 18.67 µg/g) and corn (2025.52 ± 75.83 µg/g) with significantly higher IP_6 concentration compared to other samples (Table 1). Golden apple also recorded similar IP_6 content (1945.83 ± 20.83 µg/g) but this was unexpected as analyses were carried out on the fruit itself and not on the seed portion. This is of significance as golden apple (referred to as Jew plum in some countries), is one of the most commonly consumed fruits in the Pacific and Tropical regions. Its high IP_6 levels therefore warrant further investigations since this research suggests that high IP_6 concentrations may be found in the parts of foods other than seeds. Jackfruit seeds recorded lower IP_6 concentrations than other seed samples and this was unexpected. Bioavailability of minerals from this food source may therefore be higher than that of other seed foods, since IP_6 may act as a divalent mineral chelator especially in low mineral nutrient states. This need to be further explored since food quality is adversely affected by low mineral bioavailabity. Pimento and sorrel are versatile foods as they are used as condiments, spices and for preparing various drinks. While these samples had lower IP_6 compared to leguminaceous crops, they still had appreciable levels that can be exploited for anticarcinogenic and antioxidant properties. Other spices including ginger, onion and okra recorded low IP_6 concentrations.

It is important to assess ways in which food samples with high IP_6 concentrations can be exploited since this bioactive compound is shown to be effective in reducing the incidences and complications of numerous metabolic disorders including hyperlipidaemias, diabetes mellitus and some cancers (Lee *et al*., 2007; Lehtihet *et al*., 2004; Kumar *et al*., 2010; Vucenik and Shamsuddin, 2006). While increased consumption of these foods are encouraged, purified extracts can also be prepared and marketed for their reported health benefits

Table 2.0: Free radical scavenging activity of methanolic extracts of legumes seeds and spices

Samples	% DPPH Inhibition*	IC50 (mg/mL)
Ascorbic acid	97.42 ± 0.41[a]	0.018
Kidney bean	50.85 ± 0.13[b]	0.781
Broad Bean	9.21 ± 2.60[c]	8.976
Pigeon Peas	9.17 ± 0.86[c]	5.413
Jackfruit seeds	21.01 ± 0.55[d]	2.052
Pimento	95.54 ± 0.18[a]	0.021
Pumpkin seeds (u)	4.67 ± 0.11[c]	8.844
Pumpkin seeds (h)	4.63 ± 0.42[c]	7.618
Okra	23.51 ± 4.30[d]	2.385
Sorrel	59.52 ± 0.87[b]	0.391
Onion	8.67 ± 0.44[c]	5.779
Ginger	92.16 ± 0.52[a]	0.050
Corn	28.68 ± 0.15[d]	1.410
Golden apple	19.93 ± 0.23[d]	1.779

*The % DPPH inhibition represents the mean ± SD. +IC50 values were calculated based on duplicate analysis of each plant sample.

as nutraceuticals. This assessment of IP_6 in a wide variety of beans, seeds condiments and fruits provides us with new knowledge from which further studies can be carried out. This work indicates immense potential for increased crop production along with preparation and promotion of beneficial nutraceutical products.

It was observed thatfor some samples, IP_6 concentration deviated widely from other reported values. Differences may however be due to variations in the assessment methods used since some methods may measure all phosphate containing compounds within the sample resulting in the overestimation of IP_6 concentrations.

Bioactive compounds and Antioxidant activity

The DPPH assay is used as an indication of the free radical scavenging activity of various samples and as such may identify potentially beneficial antioxidant components. It measures the ability of the extracts to donate an H^+ ion to DPPH effectively for reducing it. Screening foods for bioactive compounds may lead to the discovery of highly active compounds with significant health benefits. Secondary metabolites including flavonoids, IP_6 and total phenolics contribute to overall antioxidant activity which was assessed by DPPH inhibition. Pimento and ginger samples (with values of 95.54 ± 0.18 % and 92.16 ± 0.52 % inhibition) recorded significantly increased antioxidant activity compared to other samples with IC50 values comparable to the ascorbic acid standard (table 2). This observation is corroborated by other studies (Padmakumari *et al*., 2011; Ghasemzadeh *et al*., 2011). These two food samples along with others are used widely in various traditional preparations as treatment for various ailments including cancers and inflammatory diseases (Tsai *et al*., 2005; Marzouk *et al*., 2007). Data on flavonoid content of similar foods from the literature is sparse, however foods with high flavonoid content are reported to have antioxidant and anti-inflammatory properties and contribute positively to cardiovascular health (Verena *et al*., 2006). The ability of ginger and pimento to reduce inflammation, among other health benefits may therefore be due in part to the high levels of flavonoids (which contribute to total polyphenolic compounds) and other phytochemicals that contribute to their overall antioxidant status and reported therapeutic benefits.

Samples of corn and ginger had significantly higher phenolic content than other samples assessed with values of 80.21 ± 2.14 mg/100 g and 87.99 ± 4.05

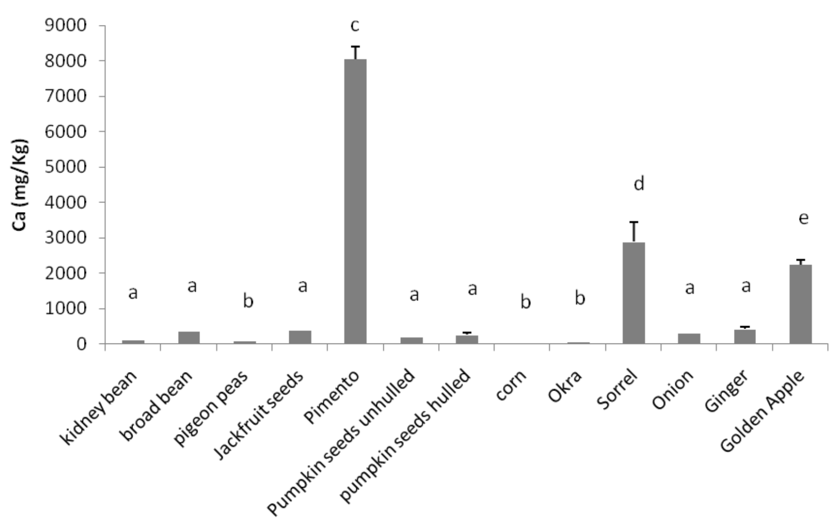

Fig 1. Calcium concentration in legumes, seeds and spices. Columns with different assigned letter superscripts are significantly different, (P<0.05). Six sample replicates were used to assess significant difference among groups.

mg/100 g respectively, while appreciable levels of polyphenols were also recorded for samples of onion (36.72 ± 1.29 mg/100 g), okra (27.95 ± 2.67 mg/100 g) and golden apple (28.25± 1.70 mg/100 g) (Table 1). We therefore theorize that other compounds in addition to polyphenols may be contributing to antioxidant activity of some samples since some samples with high polyphenol concentrations did not show high antioxidant activities. High values for DPPH inhibition were also obtained for kidney bean and sorrel samples suggesting that extracts from these foods are high in antioxidants. This research suggests that these food samples in addition to ginger and pimento, may be useful in lowering the incidences of some inflammatory diseases since foods that display high antioxidant are shown to be beneficial in this regard (Wang *et al*., 2010; Ramadan *et al*., 2011).

In light of these results, other plant preparations with similar therapeutic benefits should be assessed for overall antioxidant activity with the aim of producing nutraceutically beneficial and commercially viable proprietary preparations. Sorrel for example, matures during the winter months and the calyces of the flower are traditionally used to prepare a drink following hot water extraction. The resulting solution which has a deep red colour is reported to be high in nutrients and antioxidants and has hypolipidaemic properties (Ochani and D'Mello, 2009; Bako *et al*., 2009). Other research also suggest a role for sorrel in modulating blood pressure in hypertensive patients, with flavonoids and other phytochemicals thought to be the beneficial compounds in this regard (McKay *et al*., 2010). Our results show appreciable antioxidant activity and IP_6 in sorrel samples with only pimento samples having higher flavonoid concentrations. Further studies should be conducted and geared at identifying the specific compound or compounds responsible for the reported health benefits in this food sample. This data argues well for continued consumption and study of pimento, ginger and sorrel with the aim of correlating therapeutic benefits based on traditional knowledge with scientific data.

Minerals

Pimento samples displayed significantly higher calcium concentrations than other samples assessed with 8055.31 ± 347.60 mg/Kg as shown in Figure 1. Data from the literature on mineral content of this spice is sparse, however this research indicates that with such high calcium concentrations, pimento seeds are an

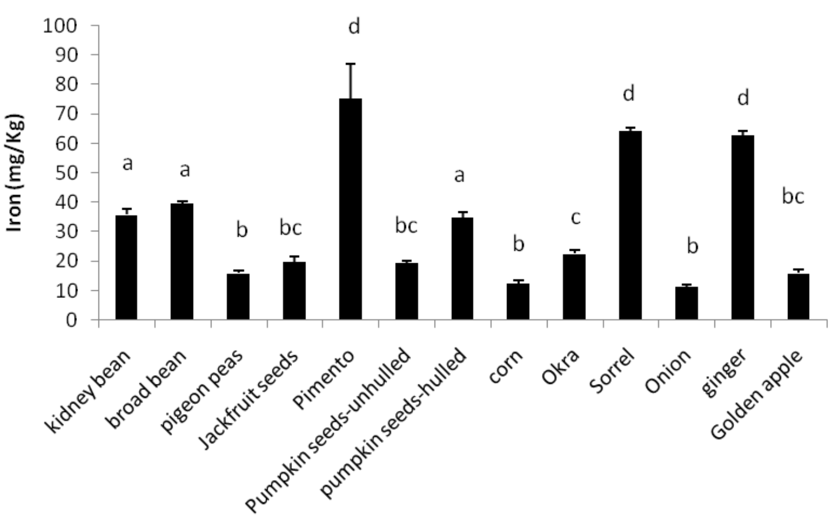

Fig 2. Iron concentration in legumes, seeds and spices. Columns with different assigned letter superscripts are significantly different, (P<0.05). Six sample replicates were used to assess significant difference among groups.

explorable source of dietary calcium. This may prove important especially in aging populations in which calcium availability and assimilation is a problem. Golden apple samples have displayed high calcium levels with a value of 2236.48 ± 140.91 mg/Kg, however the literature reports higher calcium concentrations for sorrel compared to our data (Glew *et al*., 2010). Little data is available from the literature on mineral content of golden apple samples however the level of minerals present in this fruit makes it a prime candidate for further studies. All other samples recorded calcium values of less than 1000 mg/Kg. Calcium, copper and iron content of jackfruit seeds are lower than recorded elsewhere, however higher levels of zinc were found in samples from this study compared to another recent study (Ocloo *et al*., 2010).

Calcium is important for skeletal development and integrity while also playing key roles in muscle function and transmission of neuronal impulses. Adequate intake is therefore recommended throughout life. Reduced calcium intake is of special concern in vulnerable populations including the young, the elderly and in populations with below average food intake. In addition to supplementing the diet with traditional calcium sources, increased intake of these high calcium foods identified by this study is recommended. Overall, this research shows that in addition to having high antioxidant activity, sorrel and pimento samples are also good sources of calcium. Increased utilization of these foods to supplement the diet will therefore contribute significantly to satisfy the recommended daily allowance of 100 mg for calcium.

Samples of sorrel, ginger and pimento had significantly higher iron content than all other samples analysed with pimento samples recording the highest concentrations (Figure 2). Appreciable levels of iron were also found in the samples of kidney bean, broad bean and hulled pumpkin seeds. The values recorded for iron content of pimento were notably higher than recorded elsewhere, indicating that levels of these minerals vary with geographical location and cultivation methods (Aberoumand, 2011).

Iron is an essential micronutrient with adequate levels needed for preventing anaemia. It also has important functions in cellular redox reactions. As a result foods with high levels of this mineral are therefore highly desirable. High iron content of some samples analysed make them prime candidates for micronutrient

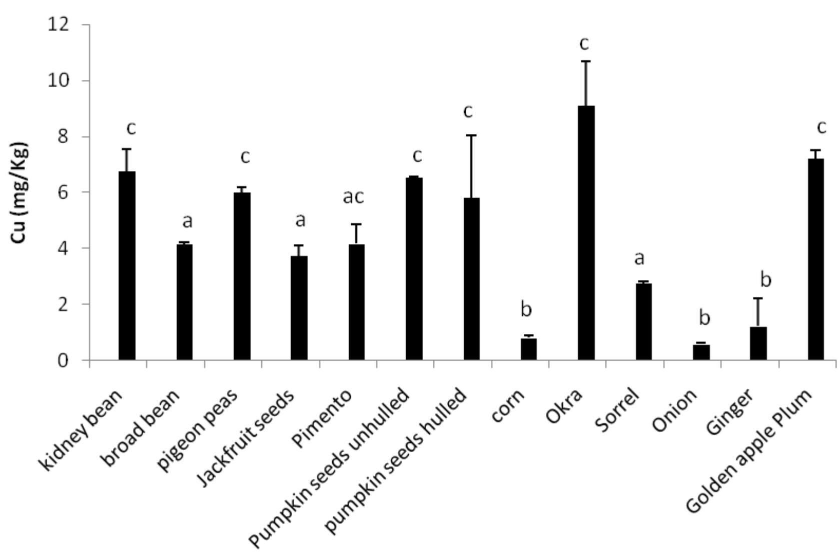

Fig 3. Copper concentration in legumes, seeds and spices. Columns with different assigned letter superscripts are significantly different, (P<0.05). Six sample replicates were used to assess significant difference among groups.

supplementation especially in mineral deficient diets. In this regard sorrel was shown to be an important micronutrient source as its addition to cakes as supplements improved calcium and iron content significantly (Almana, 2001).

In addition to high iron concentrations in sorrel (of 64.29 ± 1.06 mg/Kg), ginger (62.84 ± 1.19 mg/Kg), and pimento samples (75.25 ± 11.68 mg/Kg), we theorize that iron from these samples may also be readily available for metabolism owing to relatively low levels of mineral chelating agents in these samples compared to legumes and seeds. Further studies assessing *in vitro* bioavailability of iron are however needed since not all forms of iron present in foods are available for absorption and utilization by the body. This was highlighted in previous studies where low iron bioavailability was observed in some tuber samples with high overall iron content (Dilworth *et al*., 2007).

Zinc has many important functions including maintenance of epithelial structures, neuronal development and immune cell functioning (Haase and Rink, 2009). It is therefore important that adequate amounts are ingested since zinc deficiency is thought to be a widespread but under reported problem (Prasad, 2003). Our research shows that pumpkin seeds are an excellent source of this micronutrient (43.23 ± 0.62 mg/Kg) with significantly higher concentration than other samples assessed (Figure 4). This bears some significance as in many countries, pumpkin seeds are not normally consumed but are instead discarded. This work therefore adds to the growing body of advocating arguments for increased promotion and processing of pumpkin seeds, thereby making them suitable for wide scale consumption. The high zinc content of pumpkin seeds may also be a reason for its reported positive effects on prostate health, since adequate zinc is required for normal prostate functioning and reduced incidences of prostate cancer–specific mortality (Epstein *et al*., 2011). Pigeon peas, jackfruit seeds, okra and sorrel samples also had high levels of zinc and may also be useful in this regard. Jackfruit seeds are also not normally consumed but can be made edible after cooking. Seeds from both pumpkin and jackfruit samples which are not normally consumed should therefore be promoted for their high zinc content. These are dynamic food samples which can be prepared as snacks, appetizers or as ingredients in baked products.

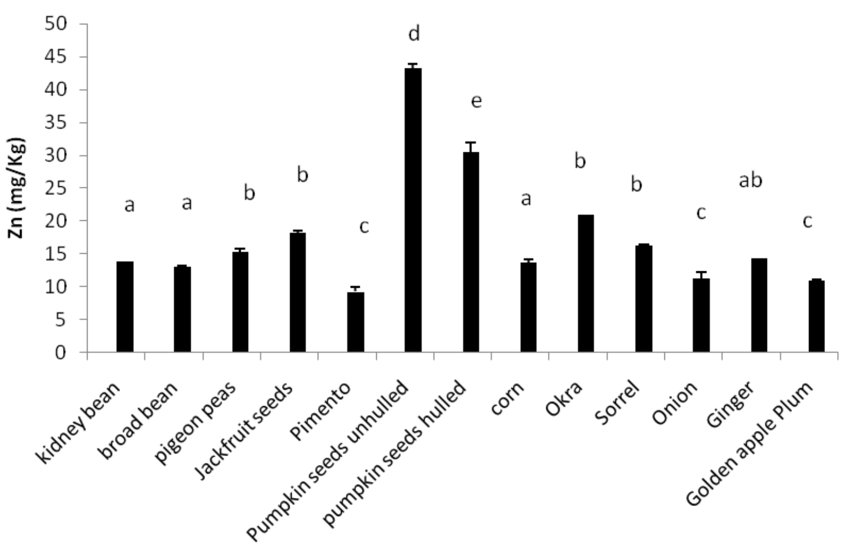

Fig 4. Zinc concentration in legumes, seeds and spices. Columns with different assigned letter superscripts are significantly different, (P<0.05). Six sample replicates were used to assess significant difference among groups.

The highest copper concentrations were observed in okra samples with values of 9.09 ± 1.57 mg/Kg (Figure 3). There were no significant variations in copper levels in approximately 50% of samples analyzed however, the levels found in corn, onion and ginger samples were significantly lower than all other samples analysed. Copper is important for electron transport and oxygen transportation and serve as a catalyst to numerous enzymes, therefore, intake of a small amount is indicated (RDA of 1.5-3 mg). Most of the food samples analysed are therefore good sources of dietary copper.

Although zinc and copper are important from a nutritional and biochemical standpoint, national food surveys have revealed marginal to moderately low contents of both nutrients in the typical American diet (Ma and Betts, 2000). From a health perspective, this is significant since there is a direct correlation between the dietary Zn/Cu ratio and incidence of cardiovascular diseases (Cabrera *et al*., 2003). Supplementing the diet with foods having sufficient zinc and copper should therefore contribute significantly to the nutritional efficacy of the typical diet and may lead to reduced incidences of cardiovascular diseases.

This research which provides information on mineral contents and other nutritional properties of food samples consumed frequently and infrequently, argues well for their increased consumption. The results of this study bears significance for the food industry, that some rarely consumed foods and food products e.g. jackfruit and pumpkin seeds should be incorporated into mainstream consumption. This could contribute to enhanced regional food security. Data also showed that dynamic ways need to be found for increased utilization of condiments and natural spices in light of their high nutrient and antioxidant properties.

CONCLUSIONS

This research shows that some food samples derived from tropical and temperate plants are high in essential minerals and bioactive compounds. Some samples displayed high antioxidant activities which may be a contributory factor to their reported therapeutic benefits as seen by their extensive use in traditional and homeopathic medicine. This work indicates that these foods should be promoted for their health benefits while further research should be geared at developing nutraceutical products from them. This work also provides evidence for increased production, preparation and consumption of some underutilized highly nutritious food samples including jackfruit and pumpkin seeds in order to supplement general or otherwise nutrient poor diets. Since preserved samples were used in this study, further comparative work should be carried out with farm fresh samples.

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DECLARATION :

The authors declare no conflict of interest.

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