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Full Length Research Paper

Iodine and inorganic mineral contents of some vegetables, spices and grains consumed in Southeastern Nigeria

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Selected vegetables, spices and grains which serve as staples in Southeastern Nigeria were analyzed for their iodine and some essential minerals. Our results showed that the mean iodine concentration of the vegetables were of 94.61 ± 15.28 µg/100 g, with Uha leaves (*Pterocarpus* spp.) having the highest with 117.66 ± 3.00 µg/100 g iodine, cowpea (*Vigna sinensis*) had the highest mean iodine concentration of 69.36 ± 7.94 µg/100 g in grains. The concentration of iodine in the spices ranged from 21.56 ± 3.6 µg/100 g in garlic (*Allium sativum*) to 95.66 ± 1.73 µg/100 g in Uziza (*Piper guineense*). Iodine was not detected in some of the plants sampled. The concentrations of the mineral elements in the vegetables, spices and grains were presented. The mineral contents indicated that, they are valuable and positive contributors to the overall iodine nutrition in the diets of the rural and urban people of Southeastern Nigeria.

Key words: Iodine, vegetable, spices, grains, goitrogen, iodine deficiency.

INTRODUCTION

No micro-ingredient is more critical to metabolism and overall health than iodine. Iodine is unique among the required trace elements because it is the constituent of the thyroid hormones. Iodine deficiency is a common cause of preventable mental defects (Hetzel, 1989; Hetzel and Wellby, 1997). Iodine is irregularly distributed over the earth's crust and in some areas the surface soil becomes progressively poorer in iodine through accelerated deforestation, soil erosion and leaching processes (EGVM, 2002; Singh, 2004). Foods grown in iodine deficient soil cannot provide enough iodine for the people and livestock living there (Koutras et al., 1985; WHO, 1996; Souci et al., 2000). Humans naturally receive their iodine by consuming plant and animal products. The intake of iodine generally corresponds to the amount entering the local food chain from geochemical environment and it is normally low from natural foods (US-FNB, 2001). For the proper utilization of iodine for thyroid hormone synthesis some mineral are required at the right concentration and proportion.

The mineral nutrients are interrelated and balanced against each other in human physiology. They cannot be considered as a single element with circumscribed functions. For instance, sodium, calcium, magnesium and phosphorus serve individual and collective purposes in the body fluid regulation. Inadequate mineral intake generally produces deficiency symptoms which include anaemia, impaired healing of wounds, delayed blood clotting severe diarrhea and chronic renal failure. Selenium and iodine ingestion have to be regulated as deficiency can lead to extreme fatigue, endemic goiter, cretinism and recurrent miscarriages (Vanderpas et al., 1990). Some inorganic mineral nutrients have been reported to be antagonistic and interfere with iodine metabolism (Underwood and Suttle, 1999; Wash, 2003). Iron (Fe) deficiency lowers the thyroid

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peroxidase activity - a heme-containing enzyme that catalyzes the initial steps in thyroid hormone synthesis. High calcium (Ca) diets or hard water high in Ca, may increase the need for additional iodine (Jooste et al., 1999). Mineral nutrient deficiencies such as zinc, copper, iron, also contribute to inability to use iodine well and this may lead to the development of Goiter (Osman and Fatah, 1981).

Mineral malnutrition can have a negative impact on thyroid function but in the presence of adequate iodine supplies, it is less common for such factors to cause problems (Gartan, 1988). High levels of minerals above the recommended daily allowance (RDA) have also been shown to be goitrogenic (Osman and Fatah 1981). This study seeks to determine the concentration of iodine and other inorganic minerals in some commonly consumed plant foods that have formed staples in the study area. The data generated may be used to work out daily intake of iodine and other inorganic minerals in the study area, thereby serving as a tool for proper nutritional planning.

MATERIALS AND METHODS

Sample collection

The samples were collected from; old market-Douglas Road, New market- Douglas Road Owerri, Umuokochi market-Nekede, Ihiagwa market and Umuokoto market-Nekede all in Imo State Nigeria. The grains sold in these markets come in from the northern region of the country while the vegetables come in from the nearby villages in Imo State. The samples were; Grains- millet (*Panicum miliaceum*) cowpea (*Vigna sinensis*) beans (*Phaseolus vulgaris*), wheat (*Triticum aeastivum*), Okpa (*Vadzeia subterranean*), groundnut (*Arachis hypogaea*), maize (*Zea may*), soybeans (*Glycine max*), rice (*Oryza sativa*) and sorghum (*Sorghum bicolor*). Spices- curry (*Muraya koenigii*), Uziza (*Piper guineense*), Nchaunwu (*Ocimium gratissium*), ginger (*Zingiber officinalis*), thyme (*Thymus vulgaris*), nutmeg (*Myristic fragrans*), rosemary (*Rosmarinus officinalis*), Uda (*Xylopia aethiopica*), bay leaves (*Laurus nobilis*), garlic (*Allium sativum*), and Utazi (*Gongronema latifolium*). Vegetables- tomatoes (*Lycopersicon esculentum*), Uha (*Pterocarpus spp*), Ugu (*Telfairia occidentalis*), Ukazi (*Gnetum africanum*) lettuce (*Lactuca sativa*), Green (*Amaranthus caudatus*), waterleaf (*Talinum triangulare*), cabbage (*Brassica oleracea*), okro (*Abelmoschus esculenta*), and garden egg leaves (*Solanum melongena*).

Sample preparation

The samples collected were oven dried at 40°C, ground to powder using warring blender, packaged in an air-tight glass jar and stored at room temperature until analysis was carried out.

Determination of iodine in plant samples

The alkaline dry ash method as described by Fisher et al. (1986) was used for this determination. This was done by adding 0.5 g of each sample into nickel crucibles. Then 1 ml of a mixture of 0.5 M sodium hydroxide and 0.1 M potassium nitrate was added to the samples, mixed and allowed to dry. The containers were then covered with aluminum foil and placed in a muffle furnace. The samples were heated to 250°C, held for 15 min, heated further to 480°C, again held for 15 min, and finally brought to 580°C. They were maintained at this temperature for 3 h, after which they were allowed to cool to room temperature. The resultant ash was extracted with three successive, 2 ml portions of a 1.0 mM sodium hydroxide solution, made up in double-distilled water.

The solution was centrifuged at 2500 g for 20 min using polypropylene centrifuge tubes and the supernatant solution collected for iodine determination. (The heat destroyed the organic matrix. The sodium hydroxide was used to keep the iodine in a nonvolatile form, while the potassium nitrate was used to increase the oxidation of the organic matter). Iodine was determined by adding 1 ml of sample solution to a cuvette at 35°C and 1 ml of arsenic reagent was added. The reaction was started by the addition of 1 ml of Ceric reagent. The initial reaction rate was calculated from the change in absorbance at 420 nm. The iodine concentrations of the samples were determined from a standard curve.

Mineral composition

2 g of each sample was transferred into a 75 ml digestion tube. 5 ml of each digestion mixture was added to each, swirled and placed in a fume cupboard. Digestion was allowed for 2 h at 150°C. These were removed from the digester, cooled for 10 min, and 3 ml of 6 N HCl was added to each tube. These mixtures were digested for another 1.5 h. The set up was removed from the digester, cooled and made up to 50 ml with distilled water. Each tube was stirred vigorously using the vortex mixer. The resulting digest was used for the determination of copper, zinc, selenium, iron, calcium and magnesium with an atomic absorption spectrophotometer (Perkin Elmner, USA).

Statistical analysis

Data obtained were expressed as means ± standard deviation and presented in bar charts and tables.

RESULTS

The iodine content of grains shown in Figure 1, ranged from 0.760 ± 0.17 µg/100 g in millet to 69.36 ± 7.94 µg/100 g in cowpea. Iodine was not detected in maize (yellow), soybeans, rice (foreign) and sorghum samples. While the distribution of iodine in spices/seasonings shown in Figure 2, ranged from 21.56 ± 3.6 µg/100 g in garlic to 108.96 ± 3.00 µg/100 g in Maggi cube. Uziza had highest iodine content of 95.66 $\underline{+}$ 1.73 µg/100 g among the spices. Iodine was not detected in nutmeg. Figure 3 showed the iodine concentration of vegetables. Iodine concentration of vegetables ranged from 66.06 ± 5.20 µg/100 g in tomato to 117.66 ± 3.00 µg/100 g in Uha leaves. The mean iodine concentration of the vegetables gave a value of 94.61 ± 15.28 µg/100 g and most of the vegetables have iodine concentration close to the upper range.

Table 1 shows the results of concentration of copper,

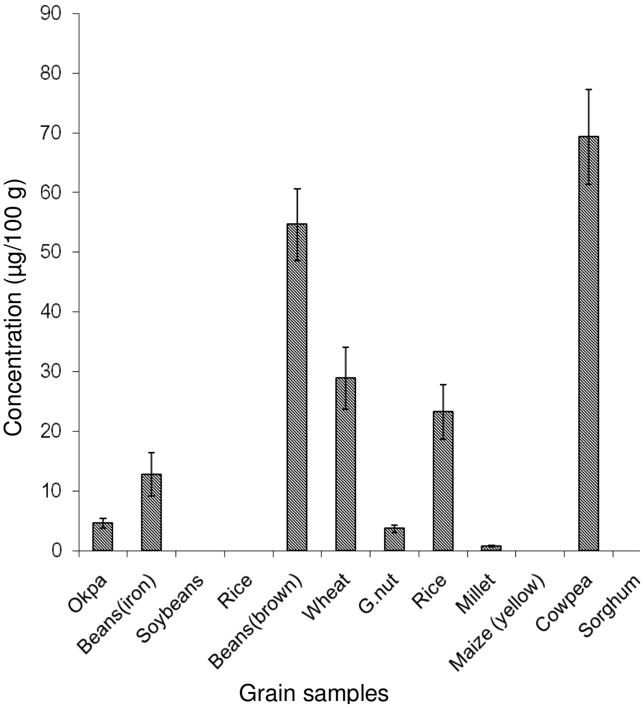

Figure 1. Profile of iodine concentration in grains.

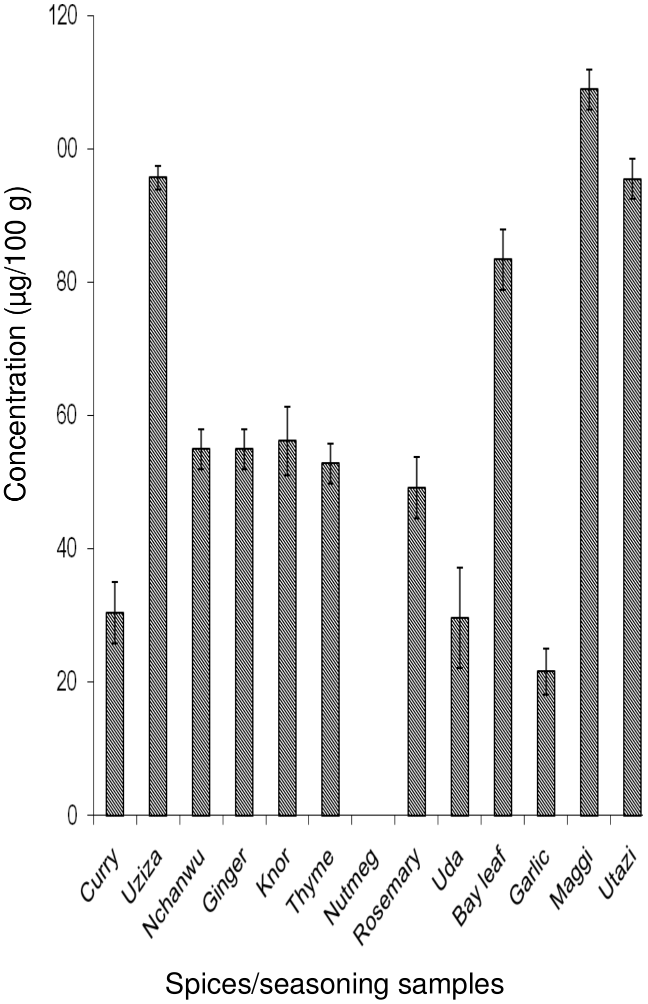

Figure 2. Profile of iodine concentration in spices/seasonings.

zinc, selenium, iron, calcium and magnesium in selected spices/seasonings. The result showed that the concentration of copper ranged from 1.93 mg/kg in Uziza to 9.84 mg/kg in rosemary leaves. Zinc concentration was highest in Knor but was not detected in Uziza, garlic and Nchanwu. Selenium was not detected in Utazi, thyme, onion and rosemary leaves but showed highest concentration of 1.90 mg/kg in curry. Iron ranged from 4.80 mg/kg in Utazi to 192.70 mg/kg in Uda. Calcium concentration ranged from 1.73 mg/kg in Utazi to 77.25 mg/kg in Uziza. Magnesium ranged from 19.17 mg/kg in Onion to 261 mg/kg in Uziza. Table 2 shows the result of concentration of copper, zinc, selenium, iron, calcium and magnesium in selected vegetables. The result showed that copper concentration ranged from 3.07 mg/kg in Okro to 28.96 mg/kg in garden egg leaves. Zinc was not detected in garden egg leaf, Green, Uha leaf, water leaf and Okro but showed highest concentration of 0.25 mg/kg in lettuce. Selenium concentration was highest in Uha leaves but was not detected in Ugu. Iron ranged from 176.60 mg/kg in Uha leaf to 2004.23 mg/kg in Green. Magnesium concentration in the vegetables ranged from 135.36mg/Kg in Cabbage to 1275.70mg/Kg in Water-leaf with a mean value of 506.30mg/kg

Table 3 shows the results of concentration of copper, zinc, selenium, iron, calcium and magnesium in selected grains. It showed that copper concentration ranged from 1.87 mg/kg in maize (yellow) to 17.29 mg/kg in groundnut. Zinc concentration of 0.22 mg/kg in maize (yellow) was the highest in the grains but was not detected in soybeans, cowpea, groundnut, and beans (brown). Selenium was not detected in wheat, maize (white), groundnut, rice (foreign), maize (yellow) and sorghum. Iron concentration ranged from 6.70 mg/kg in maize (white) to 91.90 mg/kg in wheat. Calcium concentration ranged from 0.77 mg/kg in sorghum to 22.80 mg/kg in soybeans. Also, the concentration of magnesium ranged from 39.71 mg/kg in rice (foreign) to 139.54 mg/kg in soybeans.

DISCUSSION

Our results suggest that the plants studied have varying ability to absorb iodine in its tissues, which partly supports the assumption that concentration of iodine in plant is the reflection of iodine in the soil in which it is grown (Aston and Brazier, 1979; Fuge, 2005). The result of the iodine concentration in the vegetables showed that, most of them have iodine value around the upper range of 117.66 ± 3.00 µg/100 g in Oha leaves. These vegetables iodine range are also within the upper range

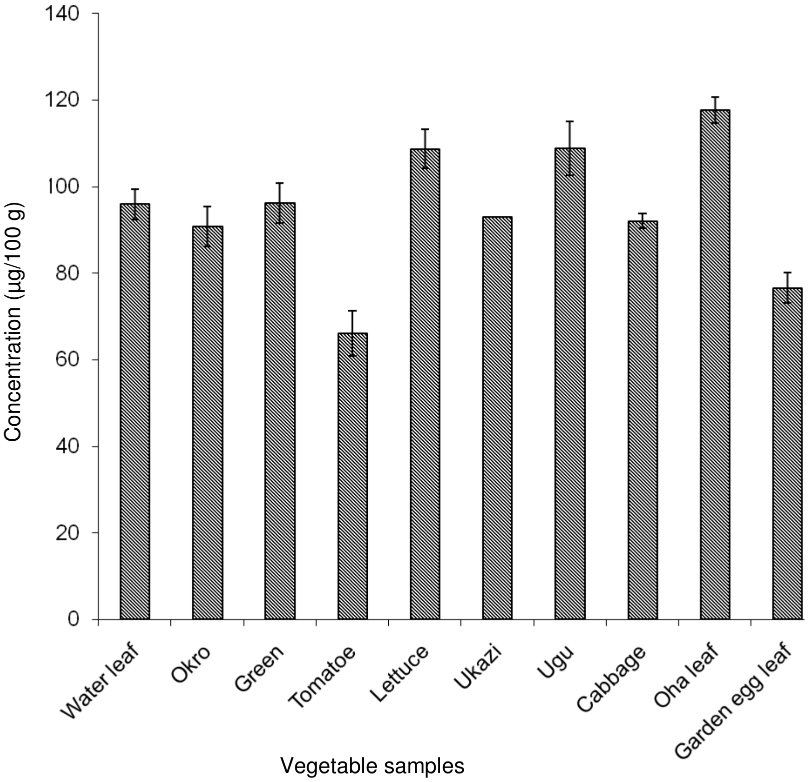

Figure 3. Profile of iodine concentration in vegetables.

of iodine level in vegetables reported by Koutras et al. (1985). The mean iodine concentration of 94.61 ± 15.28 µg/100 g of vegetables, suggests that, these vegetables studied will contribute significantly to the iodine needs of the consumers.

The results of iodine concentration of grains consumed in the south east showed that iodine concentration ranged from 0.66 ± 1.73 µg/100 g in millet to 69.36 ± 7.94 µg/100 g in cowpea and the mean was 16.49 ± 23.56 µg/100 g. These observations are quite different from the result obtained by Koutras (1985) but within the range as observed by Souci et al. (2000). This disparity can be explained by the statement given by Koutras et al. (1985) that most iodine content of food varies with geographic location because there are large variations in the iodine content of the inorganic world. These plant foods (vegetables, cereals and legumes) are staple foods of many communities in Nigeria.

The result showed that some have greater ability to concentrate iodine in their tissue than others. This is in line with the report of Howarth (1999). The knowledge of such plants would enable careful selection for consumption and iodine biofortification, where there is problem of selection. The screening of these plants grown and consumed in this geographical region (rain-forest) for their iodine content is of nutritional importance. Careful selection and combination of these plants with high iodine concentration may be of nutritional benefit for a population whose salt intake is low, either as a result of health such as hypertension or as dietary habit (Stephen and Hoption, 2006). The plants with low iodine content are not without benefit. In iodine deficient areas, where introduction of iodine salt may trigger hyperthyroidism (Barbara, 1994), careful selection of plants low in iodine concentration may be beneficial.

The results of iodine concentration of the food seasoning showed that, in the natural food seasoning (Uziza, Nchanwu, ginger, Uda, garlic and Utazi) studied, iodine concentration was highest in Uziza. The mean iodine concentration was 61.40 ± 30.58 µg/100 g. The iodine concentration in the synthetic food seasoning ranged from 30.46 ± 4.58 µg/100 g in curry to 108.96 ± 4.58 µg/100 g in maggi. The mean iodine concentration was 62.36 ± 33.19 µg/100 g. The iodine concentration in Maggi suggests a good level of iodine, because the concentration is around the upper range given for vegetables by Koutras et al. (1985) and WHO (1996). These results clearly suggest that, vegetables have the highest mean copper concentration, followed by grains and spices. These results indicate that the concentrations of copper in the plants studied cannot pose any danger of toxicity or inhibition of thyroid function with respect to the RDA (FNB-Institute of Medicine, 2001). Similarly, our bodies can regulate copper storage through excretion via the bile (Wardlaw et al., 2004; Raju and Madala, 2005). The

Table 1. Mineral concentration in selected spices/seasonings (mg/kg).

Spices	Copper (Cu)	Zinc (Zn)	Iron (Fe)	Calcium (Ca)	Selenium (Se)	Magnesium (Mg)
Piper guineense	1.93 ±0.13	ND	188.7 ±1.70	77.25 ±4.05	1.00 ±0.01	261.12 ±0.50
Gongronema latifolium	2.22 ±0.59	0.06 ±0.00	4.8 ±0.1	1.73 ±0.09	ND	41.8 ±0.38
Thymus vulgaris	6.82 ±0.08	0.08 ±0.00	60.5 ±1.20	67.99 ±0.85	ND	130.69 ±0.68
Xylopia aethiopica	2.40 ±0.82	0.07 ±0.00	192.7 ±1.70	21.78 ±0.76	0.80 ±0.01	179.49 ±2.36
Allium sativum	3.73 ±0.02	ND	34.8 ±0.10	19.04 ±2.84	0.2 ±0.01	43.34 ±1.51
Laurus nobilis	9.19 ±0.17	0.15 ±0.01	86.2 ±3.00	54.69 ±3.24	0.3 ±0.01	72.85 ±0.08
Zingiber officinalis	3.52 ±0.14	0.02 ±0.00	138.3 ±1.90	5.64 ±0.34	0.20 ±0.01	74.65 ±0.10
Allium cepa	4.58 ±0.43	0.01 ±0.00	10.4 ±2.50	7.48 ±0.89	ND	19.17 ±0.57
Knor	3.80 ±0.12	0.63 ±0.01	5.20 ±0.30	5.90 ±0.49	0.90 ±0.01	35.76 ±1.75
Muraya koenigii	2.20 ±0.06	0.16 ±0.01	160.6 ±2.00	48.63 ±0.73	1.9 ±0.01	220.65 ±2.94
Rosmarinus officinalis	9.84 ±1.06	0.02 ±0.00	12.6 ±0.40	34.31 ±1.54	ND	64.79 ±1.11
Ocimium gratissium	6.26 ±0.20	ND	101.1 ±5.40	3.77 ±0.72	0.6 ±0.01	240.26 ±0.64

Values are mean of three determinations ± SD. ND = Not Detected

very low concentration of zinc in most of the plants studied, indicates a very serious health and nutritional challenge. This is important because zinc is involved in some catalytic reaction and can stabilize the structure of some enzymes (Wardlaw et al., 2004). Also studies have shown that low zinc intake exacerbates the effect of low iodine intake (Walsh, 2003). Although, the population of the study area have been shown to consume iodized salt, which puts median urinary iodine excretion of their pregnant women within the normal range (Ujowundu et al., 2010). Zinc intake from other food sources or supplementation should be encouraged. Zinc supplementation has been reported to have favorable effect on thyroid hormone levels, particularly total T_3, and resting metabolic rate (Maxwell and Volpe, 2007).

Selenium was not detected in some of the plants studied and in those present, the concentration was very low. Selenium is an important component of iodoperoxidase, an enzyme that is involved in the production of the thyroid hormone and this suggests that, selenium deficiency contributes to the development of goiter even in the presence of adequate iodine intake (Sunde, 2001; Wardlaw et al., 2004). Selenium is a component of the enzymes deiodinase

Table 2. Mineral concentration in selected vegetables (mg/kg).

Vegetables	Copper (Cu)	Zinc (Zn)	Iron (Fe)	Calcium (Ca)	Selenium (Se)	Magnesium (Mg)
Telfairia occidentalis	8.46 ±0.82	0.12 ±0.06	248.83 ±0.06	9.09 ±0.38	ND	247.45 ±2.72
Lactuca sativa	8.64 ±0.04	0.25 ±0.08	416.9 ±7.60	49.02 ±2.11	0.2 ±0.00	268.3 ±1.63
Solanum melongena	28.96 ±2.26	ND	182.7 ±9.60	154.97 ±1.06	1 ±0.00	514.47 ±9.38
Amaranthus caudatus	10.21 ±0.45	ND	2004.2 ±0.10	127.8 ±6.23	0.6 ±0.03	1222.4 ±18.92
Pterocarpus spp	10.5 ±0.14	ND	176.6 ±9.60	59.91 ±1.65	1.6 ±0.05	260.71 ±0.03
Gnetum africanum	17.46 ±2.44	0.21 ±0.07	1723 ±0.03	68.18 ±2.25	0.1 ±0.00	215.94 ±0.29
Talinum triangulare	7.22 ±0.15	ND	510.56 ±1.10	68.54 ±1.95	0.2 ±0.03	1275.7 ±30.56
Abelmoschus esculenta	3.07 ±0.58	ND	250.47 ±0.1	99.87 ±2.92	1.3 ±0.02	416.38 ±2.99
Brassica oleracea	7.56 ±0.70	0.14 ±0.05	210.33 ±3.40	37.28 ±1.45	0.3 ±0.05	135.36 ±1.03

Values are mean of three determinations ± SD. ND = Not Detected

and thyroperoxidase, vital for the synthesis of thyroid hormones – T_3 and T_4 (EGVM, 2002; NNT, 2002). Selenium content of foods depends on the level of selenium in the soil (Wardlaw et al., 2004; Raju and Madala, 2005). The low concentration and total absence of selenium in some of the plants studied suggests that, dietary intake from natural sources may not supply the adequate amount required to carry out metabolic processes in which selenium are needed. Therefore, to meet the RDA of 55 µg/day selenium fortification may be necessary (FNB-Institute of Medicine, 2001). This indicates that the consumption of food seasonings rich in selenium such as curry powder and Uziza leaves as shown in this study should be encouraged.

Iron plays an important role in many parts of the body, including immune function, cognitive development, temperature regulation, energy metabolism, and work performance (FNB, 2001). Some iron rich foods are poor sources of the mineral because other compounds render it non-absorbable. Most contain considerable oxalate, which chelates iron and renders it non-absorbable (Lehninger, 1982; Raju and Madala, 2005). This statement is in line with the results obtained which showed that, vegetables had the highest iron concentration (176.60 to 2004.23 mg/kg). The bioavailability of the iron present in a meal depends on its form and the presence or absence of factors that influence absorption (Wardlaw et al., 2004; Yip, 2001).

Calcium ions are involved in blood clotting, nerve impulse transmission, muscle contraction (Vander, 2001). Dairy products are very good sources of calcium, green vegetables are good sources also but the presence of oxalic acid for example in spinach, renders or makes it non-absorbable (Wardlaw et al., 2004). The calcium in cereals is not also readily absorbable because it is tightly bound to inositol hexaphosphate, called phytate (Lehninger, 1982). The effects of plant calcium on thyroid function have attracted less study. However, a high calcium level in drinking water may slow iodine absorption resulting in goiter, particularly if the iodine level is borderline in meeting body needs. Magnesium is found in chlorophyll, therefore green leafy vegetables are rich sources (Wardlaw et al., 2004). This was evident in the results

Table 3. Mineral concentration in selected grains (mg/kg).

Grains	Copper (Cu)	Zinc (Cu)	Iron (Fe)	Calcium (Ca)	Selenium (Se)	Magnesium (Mg)
Phaseolus vulgaris (iron)	±0.05	0.07 ±0.01	40.1 ±5.40	13.98 ±1.04	1.6 ±0.00	130.35 ±1.57
Triticum aeastivum	2.77 ±0.13	0.07 ±0.01	91.9 ±13.1	5.91 ±0.14	ND	109.03 ±0.78
Glycine max	3.45 ±0.30	ND	43.3 ±10.1	22.8 ±0.37	0.4 ±0.00	139.54 ±1.26
Vadzeia subterranean	6.46 ±0.26	0.01 ±0.00	23.1 ±4.80	1.86 ±0.69	1.8 ±0.03	137.65 ±0.40
Zea may (white)	2.00 ±0.8	0.02 ±0.00	6.7 ±0.7	3.24 ±0.84	ND	54.47 ±0.31
Vigna sinensis (akidi)	8.96 ±0.88	ND	24.6 ±0.71	5.16 ±0.30	1.8 ±0.07	138.68 ±1.15
Panicum miliaceum	3.51 ±0.04	0.1 ±0.00	29.8 ±2.60	5.61 ±0.61	3.5 ±0.60	100.98 ±40
Arachis hypogaea	17.29 ±3.16	ND	12.1 ±0.20	5.35 ±0.73	ND	105.99 ±0.59
Oryza sativa (foreign)	8.54 ±0.77	0.02 ±0.00	15.9 ±0.50	4.71 ±1.22	ND	39.71 ±2.05
Phaseolus vulgaris (brown)	4.38 ±0.19	ND	15.3 ±0.80	7.41 ±0.25	1.4 ±0.04	130.33 ±1.00
Zea may (yellow)	1.87 ±0.25	0.22 ±0.05	30 ±5.00	3.77 ±81	ND	94.9 ±0.36
Sorghum bicolor	4.25 ±0.17	0.01 ±0.00	25 ±2.30	0.77 ±0.07	ND	100.91 ±0.29

Values are mean of three determinations ± SD. ND = Not Detected

obtained, in which vegetables showed the highest mean magnesium concentration of 506.30 mg/kg. Magnesium decreases blood pressure by dilating arteries, and preventing heart rhythm abnormalities (FNB, 1997).

Conclusion

Our results suggest that, iodine concentration in the soil and water media contains iodine at a concentration that can only supply moderate iodine to the plants grown in the environment and to the population that consume the plants. The iodine concentration in the plants studied showed variation in the iodine concentration. These iodine contents could only provide moderate iodine which is not sufficient for optimal thyroid function. This suggests that the combination of these plants could provide enough to meet RDA of iodine. Also, the concentrations of the inorganic minerals were not at levels that may cause negative impact on thyroid function.

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