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MINERAL CONTENTS OF SOME INDIGENOUS VEGETABLES OF GHANA

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Abstract

The aim of the study was to determine the concentrations of mineral nutrients present in eight indigenous vegetables of Ghana, namely; young cocoa fruit (*Theobroma cacao*), unripe pawpaw fruit (*Carica papaya*), mature fruits of "kwaansusuaa" (*Solanum nigrum*), leaves of "eyoyio" (*Corchorus tridens*), leaves of sweet potato (*Ipomea batatas*) and "alefi" (*Amarantus*) *incurvatus*) leaves. Mineral nutrients assessed included calcium, iron, phosphorus, potassium, sodium and zinc. Potassium and sodium were analyzed using flame photometry while zinc was analyzed using Atomic Absorption Spectrophotometry (AAS). Determination of iron concentration was by α, α'-dipyridyl spectrophotometric method, and phosphorus was based on Denigés reaction using molybdic acid and hydroquinone. Calcium concentration was determined using Clark-Collip titrimetric method. The concentrations of all the minerals were assessed after they had been released into solution by a wet digestion process. Analysis of moisture was by the air-oven drying method, and ash by ashing in a furnace. Results, on fresh weight basis, showed that the iron concentration in the vegetables ranged from 3.45-24.08 mg Fe/ 100 g, with potatoe leaf being the richest source among the vegetables studied (24.08 mg Fe/ 100 g). Zinc concentration ranged from 0.23 - 2.05 mg Zn/100 g; calcium between 42.92 - 76.56 mg Ca/100 g and potassium 214 - 588.74 mg K/100 g of the fresh samples. The results of this study suggest that some of the vegetables could contribute substantial amounts of dietary iron and zinc.

Résumé

TAYIE, F. A. K. & ASIBEY-BERKO, E.: *Les contenus minéraux de quelques légumes indigènes du Ghana.* Le but de l'étude était de déterminer les concentrations de minéral nutritif présent enhuit légumes indigènes du Ghana, à savoir; fruit de cacao jeune (*Theobroma cacao*), fruit vert de papaye (*Carica papaya*), fruits mûrs de "Kwaansusuaa" (*Solanum nigrum*), les feuilles de "eyoyio" (*Corchorus tridens*), les feuilles de la patate douce (*Ipomea batatas*) et les feuilles de "alefi" (*Amarantus incurvatus*). Les minéraux nutritifs estimés comprenaient calcium, fer, phophore, potassium, sodium et zinc. Potassium et sodium étaient analysés en utilisant la photométrie de flamme alors que zinc était analysé en utilisant spectropotométrie d'absorption atomique (SAA). Détermination de concentration de for était pat la méthode ∝, ∝' - dipyridyl spectrophotométrique et phosphore était basé sur la réaction Denigés utilisant l'acide molybdique et hydroquinone. Concentration de calcium était déterminée en utilisant la méthode clark-collip titrimétrique. Les concentrations de tous les minéraux étaient estimées après avoir été mis en solution par le processus de digestion humide. Analyse d'humidité était par la méthode de séchage au four d'air et le cendre par cendrant dans une chaudière. Les résultats, selon le poids de produit frais, montraient que la concentration de fer dans les légumes variait entre 3.45 et 24.08 mg Fe/100 g, avec les feuilles de patate étant la source la plus riche parmi les légumes étudiés (Fe/100 g). Concentration de zinc variait entre 0.23 et 2.05 mg Zn/100 g; calcium entre 42.92 et 76.56 mg Ca/100 g et potassium entre 214 et 588.74 mg K/100 g d'échantillon frais. Les résultats de cette étude suggèrent que quelques légumes porraient contribuer des quantités substantielles de fer et de zinc diététiques.

Introduction

Plant parts usually eaten cooked or raw as part of a meal are usually referred to as vegetables (Hart & Fisher, 1971; Duckworth, 1966). Although there are many vegetables commonly eaten in Ghana, there are some indigenous ones that are less popular. Some of these vegetables are eaten either for a specific purpose or in periods of food shortage. For instance, "kwaansusuaa" (*Solanum nigrum*) is a main ingredient of the diet of lactating mothers in Ghana, where it is believed to help the mother regenerate her lost blood and to enhance her ability to breastfeed. The drought in Ghana during 1983-1984, which resulted in a nation-wide food shortage led to the re-discovery of some hitherto obscure vegetables. Among the ones that gained popularity were young cherelles of the cocoa fruit (*Theobroma cacao*) and the young tender leves of "eyoyio" (*Corchorus tridens*) as alternatives for okro. Unripe fruits of the pawpaw plant (*Carica papaya*) for a brief period served as garden eggs or egg plant. The green berries of "kwaansusuaa", the leaves of sweet potato (*Ipomea batatas*) and "alefi" (*Amarantus incurvatus*) also gained more acceptance. These vegetables, less popular as they seem, have not attracted the attention of nutritionists for the analysis of their mineral contents. Their proximate composition, however, has been studied earlier (Asibey-Berko & Tayie, 1999).

The listed vegetables, even though less popular in Ghana, are eaten more frequently in other West African countries. For instance, "eyoyio", which is also called "West African sorrel", is one of those eaten frequently in other West African countries such as Togo, Sierra Leone and Cote d' Ivoire (FAO, 1988). The young leaves and shoots of "eyoyio" produce a popular mucilaginous dish when cooked and are eaten with other vegetables like tomatoes, and oil and groundnut paste (FAO, 1988). In Cote d' Ivoire, the consumption of "kwaansusuaa" also called "black night shade" is also widespread (FAO, 1988). The green fruits are usually cooked in stews, steamed or used as a relish. In some countries, like Sierra Leone, the young tender green unripe cocoa fruits are used as boiled vegetables. The young green unripe tender pods are pounded in a mortar and used as the basis for soups and stews, where it produces mucilage to give a slippery texture on cooking, and can be served with rice. This preparation is regarded as a special dish served to visitors and strangers (FAO, 1988). In most West African countries, the fresh leaves of "alefi" are picked, washed and chopped and used as greens in salads, stews and soups. (FAO, 1988). In Ghana "alefi" was called "poor mans meat" in the drought period of 1983-1984.

There is a dearth of data on the mineral contents of the listed vegetables. However, White & Selvey (1974) studied some other vegetables and reported the calcium contents of spinach, lettuce and cabbage to be 93, 20 and 49 mg /100 g, respectively. They reported the phosphorus contents of lettuce and cabbage to be 22 and 29 mg/ 100 g, respectively (White & Selvey, 1974).

Experimental

Sample collection and precautionary measures

In order to obviate the effects of different environments and soil types on nutrient contents, care was taken to obtain the fresh samples from multiple locations (Passmore & Eastwood, 1986) about 4-90 km apart, namely Agona Swedru, Kasoa, Accra and Cocoa Research Institute at Tafo. The young cocoa fruits (cherelles) were collected from four different locations. Alefi and potato leaves were each obtained from two different localities. Eyoyio, kwaansusuaa and unripe pawpaw fruits were collected from three different localities. On the field, freshly collected samples were packaged in polyethylene bags and kept on ice in an ice-chest for transport to the laboratory. Moisture was determined immediately on fresh edible portions of the samples. Edible portions of remaining fresh vegetables were dried to constant weight. The oven temperature was set at 90 °C to retain volatile constituents. For each batch of sample, all dried sub-samples were pooled together and ground into a composite powder. Each composite powdered sample from a locality was analyzed

in duplicate so that a sample obtained from two localities will have four replicate results. The samples were packaged in air-tight polyethylene bags and stored in a freezer at - 4 °C for the analyses. Glassware were acid-washed using 2 *M* HCl, rinsed several times in distilled water, then in deionized water and, thereafter dried, before use. Where titration was involved, all titre values were corrected with blank (control) values. Each mineral determination was done along with a check digest solution of known concentration prepared from a wheat-flour quality control sample which had already been standardized through the usual protocol. To avoid loss of some volatile mineral elements present in the vegetables, nitric acid was used for the wet digestion. The wet digestion was done in a fume chamber because of the dangerous evolution of acid fumes.

Chemical analysis of nutrients

Wet digestion of the samples. This was done using the method described by Pearson (1976). About 1.0 g of each vegetable contained in an Erlenmeyer flask (250 ml capacity) was completely oxidized by gentle heating on an electric hot plate after addition of 25. 0 ml concentrated HNO_3. After the evolution of brown fumes had stopped, 1.0 ml 70% perchloric acid (Analar grade) was added and heating continued until a clear light yellow solution was obtained. At this stage, 30 ml of hot deionized water was added to the digest and heated to boiling. The resulting solution was filtered hot, using ashless clean Whatman filter paper (No. 43) into a previously acid-washed 100 ml volumetric flask. More deionized water was then added to make up to the 100 ml mark. For each composite sample, duplicate digest solutions were prepared. The wet digest solutions were prepared on the same day for each sample as the check sample and duplicate blanks. The wet digestion was done to obtain clear solutions of the minerals contained in a known weight of a vegetable to enable subsequent determination of their concentrations in the vegetable.

Total moisture. For moisture determination, 2 g of each vegetable in duplicate sample was weighed using a sensitive electronic weighing scale (OHAUS Galaxy 160D) and samples dried to a constant weight overnight (at least 12 h) at 105 °C in an air-oven (Bird and Tatlock London - BS 2648) in well labelled moisture dishes, using the method described by Osborne & Voogt (1978).

Total ash. The amount of ash in each vegetable was determined using a dry ashing method described by Pearson (1976), using 2 g of sample in a porcelain dish in a muffile furnace (Neytech 130-A) at 600 °C.

Determining the concentration of minerals

Calcium. The concentration of calcium in the vegetables was determined using the Clark-Collip titrimetric method (AOAC, 1990), which is based on the precipitation as calcium oxalate of the calcium from the solution of minerals. The calcium oxalate was separated by filtration and then redissolved in hot 20% sulphuric acid. The resulting solution was finally titrated with a standard solution of potassium permanganate (0.02 *N* $KMnO_4 \equiv 0.0004$ g of calcium).

Iron. Concentration of iron in the vegetables was determined using the α, α'-dipyridyl spectrophotometric method documented by the American Association of Cereal Chemists (AACC, 1962). The absorbance of the red colour developed in the mixture by the reaction of iron and α,α'-dipyridl, the intensity of which is directly proportional to the concentration of iron, was determined using a sensitive spectrophotometer (Shimadzu UV 120-02) taking readings at 500 nm. A standard curve developed using standard iron solutions enabled quantification of concentration of iron in the vegetables.

Phosphorus. Determination of the concentration of phosphorus was based on Denigés reaction in which the phosphorus in the digest solution was used to produce phosphomolybdate which was then reacted with hydroquinone to produce a stable blue colour (Pearson, 1976). The intensity of the blue colour is directly proportional to the concentration of phosphorus in the digest.

Reading the absorbance of the standard and the blank digest solutions at 680 nm, a standard curve was developed for the determination of concentration of phosphorus in the test solutions.

Sodium and potassium. The concentrations of sodium and potassium in the digest solutions, and, hence, in the vegetables were determined by a procedure described by Osborne & Voogt (1978) using a flame photometer (Shimadzu 480 k). The concentrations of sodium and potassium in the digest solutions were determined by comparing the readings of the test solutions with a 100 per cent full-scale deflection of standard solutions which contained both sodium and potassium.

Zinc. The concentration of zinc in the vegetables was determined using an Atomic Absorption Spectrophotometer (Perkin-Elmer 2280) with the monochromator set at 213.9 nm and satisfying the other settings for zinc determination by AAS (Pearson, 1976).

Results and discussion

Studying the results obtained in this study (Table 1), an outstanding finding was the concentration of iron in the leaves of the potato plant (*Ipomea batatas*); 24.08 ± 0.12 mg/100 g, and "eyoyio" (*Corchorus tridens*); 21.56 ± 0.03 mg/100 g of the fresh sample, that were substantial. The concentrations of calcium even though low (range; 17.91 - 97.63 mg/100 g) were uniformly higher than that of phosphorus (range; 7.42 - 48.95 mg/100 g) in the vegetables. The concentrations of sodium in the vegetables were low, ranging from 6.68 - 21.82 mg/100 g. The vegetables studied were, how-

TABLE 1

Mineral contents of some indigenous vegetables of Ghana (per 100 g fresh edible portion)

Common names	*Eyoyio*	*Alefi*	*Kwaa-nsusuaa*	*Young cocoa fruit*	*Sweet potato leaves*	*Unripe pawpaw fruit*
Botanical names	Corchorus tridens	Amaranthus incurvatus	Solanum nigrum	Theobroma cacao	Ipomea batatas	Carica papaya
Moisture (%)	82.79 ± 0.02*	90.30 ± 0.56	80.39 ± 1.30	85.02 ± 0.40	83.71 ± 0.15	91.60 ± 0.16
Ash (g/100 g)	1.48 ± 0.07	1.38 ± 0.35	0.80 ± 0.08	1.06 ± 0.08	1.31 ± 0.07	0.32 ± 0.02
Iron (mg/100 g)	21.56 ± 0.03	10.35 ± 0.77	14.59 ± 0.17	14.79 ± 0.14	24.08 ± 0.12	3.45 ± 0.03
Phophorus (mg/100 g)	35.36 ± 0.99	18.77 ± 0.45	40.73 ± 1.07	48.95 ± 5.77	32.19 ± 0.91	7.42 ± 0.46
Calcium (mg/100 g)	76.56 ± 5.72	52.45 ± 8.97	42.92 ± 1.24	97.63 ± 2.70	65.28 ± 3.10	17.91 ± 1.60
Potassium (mg/100 g)	588.74 ± 1.25	591.06 ± 1.50	528.72 ± 1.15	428.84 ± 1.04	546.33 ± 2.34	214.42 ± 1.86
Sodium (mg/100 g)	17.07 ± 2.34	20.56 ± 1.30	9.54 ± 0.84	6.68 ± 1.58	21.82 ± 1.16	6.44 ± 1.08
Zinc (mg/100 g)	1.76 ± 0.18	1.16 ± 0.12	2.05 ± 0.20	0.87 ± 0.12	0.95 ± 0.10	0.23 ± 0.02

* Mean ± SD

ever, moderate sources of zinc (range 0.23 - 2.05 mg/100 g). As expected for most vegetables, the concentrations of potassium were quite high (range 214.42 - 591.06 mg/100 g). The vegetables were high moisture foods, the total moisture contents ranging from 83.71 - 91.60 per cent. The ash contents of the vegetables were in the range found in most vegetables (range 0.32 - 1.48 g/100 g) (Table 1).

Results of this study suggest that generally, the vegetables under study are not outstanding sources of minerals and nutrients, though they compare well with the general concentrations of minerals found in vegetables commonly consumed in Ghana. Of particular interest were the concentrations of iron, zinc and calcium in the vegetables, taking cognisance of their importance in human nutrition and the difficulty in meeting daily needs. *Solanum nigrum* ("kwaansusuaa), which is a common ingredient in the diet of pregnant and lactating Ghanaian women, was found to contain only moderate concentrations of iron. Thus the hematopoietic property claimed for *Solanum nigrum* is probably not due to a high iron content. However, *Solanum nigrum* was the richest source of zinc among the vegetables studied (Table 1). The leaves of "alefi" (*Amaranthus incurvatus*), which was termed "poor man's meat" during the Ghanaian drought of 1983, was found to contain moderate amounts of the minerals and its zinc content was similar to that of spinach (1.16 mg *vrs* 1.30 mg/100g, respectively) (Whitney & Hamilton, 1984). The vegetables were not rich sources of calcium but compared favouably with common vegetables. The calcium content found for the cocoa cherelles, for example, was 97.63 mg/100 g, similar to that contained in spinach, 93 mg/100 g. The concentrations of calcium in the vegetables were higher than that of phosphorus. This observation favours a higher calcium to phosphorus ratio which is an important favourable factor to consider in the absorption of these two minerals, in view of their interaction through competitive absorption.

The unripe mature fruits of the pawpaw plant (*Carica papaya*) appeared inferior to all the leafy vegetables studied in terms of mineral contents, but compared well with the mineral composition of most fruits. The zinc concentration reported by Anderson & Dibble (1982) for orange fruit, for example is 0.20 mg/100 g, while that for the pawpaw fruit was 0.23 mg/100/g. It has been reported that the concentration of nutrients and minerals in vegetable and fruits depend on the stage of maturity; as the vegetable matures its mineral concentrations increase (Whiteacre *et al.*, 1944; Pepkowitz *et al.*, 1944; Flynn Hibbarbi & Hagan, 1944). Thus, a ripe pawpaw, eaten as a fruit, may contain more minerals than the green kind used as a vegetable.

The bioavailability of the minerals, especially iron and zinc, in the vegetables studied may be low because of the high concentration of dietary inhibitors such as fibre and tannins (UNICEF and Micronutrient Initiative,1998). The non-heme nature of the iron present in the vegetables in addition to the effects of dietary inhibitors makes only a small fraction, about 5 per cent, to be absorbed from vegetable diets (UNICEF and Micronutrients, 1998). However, depending on the iron nutrition status, the physiological state of a person and the presence or absence of dietary enhancers in the diet, an amount ranging from 1-40 per cent or iron could be absorbed from the vegetable diet (UNICEF and Micronutrient Initiate, 1998). The absorption of iron is on the high side if the diet is well balanced with animal protein and fruit juice. Dietary zinc bioavailability has been reported to be altered by similar conditions that affect iron absorption.

The vegetables studied were found to be moderate sources of the minerals analyzed. Existing conditions (physiological and dietary) and frequency of intake could contribute substantial amounts of these minerals to dietary intake, especially from a vegetable based diet.

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