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ORIGINAL ARTICLE

Calcium Analysis of Selected Western African Foods

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Because mineral composition data for Western African foods are incomplete, it is essential to obtain analyses of foods in order to assess the quality of existing food as well as to estimate dietary intake of various minerals, such as calcium. Twenty-eight Western African foods were analyzed for calcium using the method described by Ferguson *et al*., (1993) and the Association of Official Analytical Chemists (AOAC) (Padmore, 1990). Calcium concentrations were determined using an inductively coupled plasma atomic emission spectrophotometer (ICP). Calcium recovery was 94.4% of the expected value with respect to a standard reference material (corn husk). For all foods assessed, the content of calcium ranged from 3.04 to 3630 mg/100 g dry wt. Based on dry weight, the top five foods for calcium in rank order were sorrel leaves (3630 mg/100 g), amaranth leaves (3590 mg/100 g), okra leaves (2850 mg/100 g), onion leaves (2540 mg/100 g), and baobab leaves (2240 mg/100 g). Data from this study provide calcium analyses of some commonly eaten Western African foods, which should help in planning food-based intervention programs to improve mineral nutrition.

Key Words: African food analysis; calcium.

INTRODUCTION

Because mineral composition data for Western African foods are very limited, food analyses are essential in order to assess the quality of existing foods as well as to estimate dietary intake of various nutrients. Few studies of Western African foods have documented the importance of green leaves and other wild foods as well as their contribution to calcium nutrition (Ferguson *et al*., 1988, 1993; Nordeide *et al*., 1994, 1996). Mineral deficiencies, such as calcium, are a world-wide problem particularly in developing countries. If foods rich in minerals are identified and prepared by methods known to enhance mineral bioavailability such as fermentation, soaking and malting, mineral nutrition can be improved. In developing countries like those of Western Africa, the average daily calcium intake is very low, ranging between

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300 and 500 mg for adults. Unfortunately, milk products are scarcely consumed (Prentice *et al*., 1993). The reliance on plant calcium sources is very important. The analysis of calcium within commonly eaten Western African foodstuffs is, therefore, needed which is the purpose of this study. These data should be a valuable resource allowing better food selection and consequent improvement in nutritional status.

METHODOLOGY

Dried food samples were purchased from merchants in various markets in Benin and Mali. Choices of food were based on seasonal availability and those commonly consumed. Other samples were purchased from a large Western African retail outlet in Washington, DC. It is felt that data are more useful in determining intake when samples are collected close to the point of actual consumption. Foods were kept at -20°C prior to assay work. Samples were analyzed in duplicates using the methods of Ferguson *et al*., (1993) and the Association of Official Analytical Chemists (AOAC) (Padmore, 1990). Each food sample was placed in an aluminum tin and weighed on a Mettler type AE100S analytical balance. The sample was then dried to constant weight at 98°–100°C using a Precision vacuum oven Model 10. The samples were cooled in a desiccator and weighed as soon as they reached room temperature (Padmore, 1990). Each sample was then ground using an acid-washed ceramic mortar and pestle. After grinding, the samples were again dried to constant weight and stored in a desiccator until dry ashing. One gram of each food sample was weighed on an analytical balance and placed in a porcelain crucible and covered. The crucibles were put into an electric muffle furnace and burned for 15 h at 450°C. After cooling, several drops of analytical grade nitric acid were added to the ash and the suspension was again ashed for 15 h at 450°C. After the final ashing, the crucibles were cooled to room temperature and the ash was suspended in 5 mL of 6 N ultra-pure hydrochloric acid. The solution was transferred to a 25 mL flask and deionized water was added to volume. Calcium content was analyzed using an inductively coupled plasma atomic emission spectrophotometer (ICP-AES) with data converted to mg/100 g of food. For verification of the methods used, a corn husk standard reference material 8412 (National Institute of Standards and Technology, Gaithersburg, MD) was analyzed for calcium and percent of calcium recovered calculated. Dry weight data are reported because, in Western Africa, these foods are purchased and used in the dry state (Bendech *et al*., 1995, 1996).

RESULTS AND DISCUSSION

A total of 28 different foodstuffs were analyzed including nine vegetables (mainly green leaves), six cereal grains and grain products, five tubers, roots and products, six dried legumes, one nut, and one seed. The English, Latin and French names for plants studied are listed in Table 1. The corn husk standard listed calcium as 2160 ± 80.0 S.E. μg/g. Recovered calcium was 2040 ± 29.2 S.E. μg/g or 94.4%. For all the foods analyzed, the calcium content is reported as mg/100 g dry weight since these foods are purchased and used dry by the Western African populations. For all foods, the calcium content ranged from 3.04 to 3630 mg/100 g dry wt.

Table 2 displays the calcium content (mg/100 g dry wt.) of the foods analyzed. Sorrel leaves had the highest calcium content (3630 mg/100 g dry wt.), and corn flour with bran had the lowest calcium content (3.04 mg/100 g dry wt.). The top five foods in rank order were sorrel leaves, amaranth leaves, okra leaves, onion leaves, and baobab

TABLE 1

Selected African foods analyzed

English name	Latin name	French name
Okra	*Hibiscus esculentus*	Gombo
Bambara beans	*Voandzeia subterranean*	Voandzou
Peanut	*Arachis hypogaea*	Arachide
Amaranth leaves	*Amaranthus* spp.	Amaranthe
Squash	*Cucurbita* spp.	Courge
Baobab leaves	*Adansonia digitata*	Baobab
Sorrel leaves	*Hibiscus sabdariffa*	Oseille de Guinée
Eggplant leaves	*Solanum macrocarpon*	Aubergine indigène
Jute leaves	*Corchorus olitorius*	Jute
Onion	*Allium cepa*	Oignon
Corn flour	*Zea mays*	Maïs
Taro	*Colocasia esculenta*	Taro
Yam	*Dioscorea* spp.	Igname
Cassava	*Manihot esculenta*	Manioc, cossettes
Sweet potato	*Ipomoea batatas*	Patate douce
Millet	*Eleusine coracana*	Mil
Sorghum	*Sorghum* spp.	Sorgho
Pigeonpea whole seed	*Cajanus cajan*	Pois d'Angole
Soybean, white	*Glycine* spp.	Soja
Soybean, green	*Glycine* spp.	Soja
Black-eyed peas	*Vigna unguiculata subsp*	Haricot indigène
Cashew	*Anacardium occidentale*	Noix de cajou

TABLE 2

Calcium content of commonly eaten Western African foods

Food name[1]	*n*	Mean calcium content mg/100 g dry wt.	S.E.
Okra, dried	4	1330	353
Okra, leaves, dried	2	2850	—
Bambara beans, dried[2,3]	6	47.3	11.1
Peanut, shelled, dried	2	38.5	—
Amaranth, leaves, dried	3	3590	669
Squash seed, dried, without shell[3]	3	68.6	2.50
Baobab, leaves, dried[3]	6	2240	196
Sorrel, leaves, dried	1	3630	—
Formula 1, flour[4]	2	96.1	—
Formula 2, flour[5]	2	72.5	—
Eggplant leaves, dried	2	1590	—
Jute, leaves, dried	1	1110	—
Onion, leaves, dried[2]	2	2540	—
Onion, dried[2]	2	354	—
Corn flour with bran	2	3.04	—
Corn flour without bran	2	4.30	—
Taro flour	2	22.7	—
Yam flour	2	20.9	—
Cassava, soaked, dried, pounded[2]	4	68.8	5.16
Cassava, meal, gari fermented, dried	2	30.6	—
Sweet potato, flour	2	27.0	—
Millet	2	12.8	—
Sorghum whole-grain, red	2	7.06	—
Pigeonpea whole seed	2	87.1	—
Soybean, white	2	331	—

TABLE 2 (Continued)

Food name[1]	*n*	Mean calcium content mg/100 g dry wt.	S.E.
Soybean, green	2	314	—
Black-eyed peas	2	73.0	—
Cashew, roasted	2	44.0	—

[1] All foods analyzed originated from Benin unless otherwise indicated.
[2] Samples purchased in Mali.
[3] Samples purchased at a retail store in Washington, DC. This store usually sells foods originating in Nigeria.
[4] Formula 1 is a mixture of corn flour without the bran, dried milk, and added vitamins.
[5] Formula 2 is a mixture of corn flour without the bran, sorghum flour, non-fat soybean flour, and vitamins.

leaves. Green leaves contained the highest calcium content while the cereal and grain group had the lowest. These findings agree with the data published by Ferguson *et al.*, (1988, 1993).

The values obtained from this study in comparison to those available in the published literature showed much agreement and some disagreement. Table 3 compares the present data to other published African values. To explain the differences, it should be noted that not all foods in the literature originated from Western Africa. For some Western African foods harvested in the same country, the mineral content, including calcium levels, can vary greatly. The plant state of maturation, genetic variances, and environmental factors are possible explanations for discrepancies observed (Nordeide *et al.*, 1996). Also, these data on Western African foods are some of the few using ICP technology.

Mineral composition in food may vary greatly depending on where the food was grown as well as analytical methods used. In future studies, stress should be placed on food processing and methods of preparation which greatly influence mineral composition and bioavailability. Additionally, focus should be directed to the ratios between calcium, zinc and phytates. It is well known that a synergism exists between calcium and zinc ions resulting in a Ca:Zn:phytate complex that is less soluble than phytate complexes formed by either ion alone (Ferguson *et al.*, 1988; Lopez *et al.*, 1983; Johnson, 1991).

TABLE 3

Calcium content of commonly eaten Western African foods compared with other Western African published data

Food name[1]	Calcium content (mg/100 g dry wt.)
Okra dried	1330
(Ferguson *et al.*, 1993)	722
(Leung *et al.*, 1968)	968
Okra, leaves, dried	2850
(Leung *et al.*, 1968)	258–635
(Dos-Santos and Damon, 1987)	47
Bambara beans, dried[2,3]	47.3
(Leung *et al.*, 1968)	29–217
(Dos-Santos and Damon, 1987)	82

TABLE 3 (Continued)

Food name[1]	Calcium content (mg/100 g dry wt.)
Peanut, shelled, dried	38.5
(Leung *et al*., 1968)	49
(Dos-Santos and Damon, 1987)	55
Amaranth, leaves, dried	3590
(Dos-Santos and Damon, 1987; Leung *et al*., 1968)	2562
(Nordeide *et al*., 1996)	2380
Squash seed, dried, without shell[3]	68.6
(Leung *et al*., 1968)	57
(Dos-Santos and Damon, 1987)	50
Baobab, leaves, dried[2]	2240
(Leung *et al*., 1968)	2241
(Dos-Santos and Damon, 1987)	1646
(Nordeide *et al*., 1996)	1810
Sorrel, leaves, dried	3630
(Leung *et al*., 1968)	1449
(Dos-Santos,1987)	1414
Eggplant, leaves, dried	1590
(Leung *et al*., 1968)	206
Jute, leaves, dried	1110
(Leung *et al*., 1968)	1540
Onion, leaves, dried[2]	2540
(Nordeide *et al*., 1996)	2070
Onion, dried[2]	354
(Leung *et al*., 1968)	235
(Dos-Santos and Damon, 1987)	286
Corn flour without the bran	4.3
(Dos-Santos and Damon,1987)	9
Taro flour	22.7
(Dos-Santos and Damon, 1987)	84
Yam flour	20.9
(Leung *et al*., 1968)	20.0
(Ferguson *et al*., 1993)	19.0
(Dos-Santos and Damon, 1987)	13.0
Cassava, soaked, dried, pounded[2]	68.8
(Dos-Santos and Damon, 1987)	14.0
Cassava, meal, gari fermented, dried	30.6
(Ferguson *et al*., 1993)	38
(Leung *et al*., 1968)	45
(Dos-Santos and Damon, 1987)	34
Sweet potato, flour	27.0
(Ferguson,1988)	24
(Ferguson *et al*., 1993) boiled	50
(Dos-Santos and Damon, 1987)	113
Millet	12.8
(Leung *et al*., 1968)	10–67
Sorghum whole-grain, red	7.06
(Ferguson *et al*., 1993)	18
(Leung *et al*., 1968)	10–41
(Dos-Santos and Damon, 1987)	21
Pigeonpea whole seed	87.1
(Ferguson,1988)	121
Soybean, white	331
(Leung *et al*., 1968)	183–249
Black-eyed peas	73.0
(Leung *et al*., 1968)	101
(Dos-Santos and Damon, 1987)	85
Cashew, roasted	44.0
(Leung *et al*., 1968)	53–143

[1] All foods analyzed originated from Benin unless otherwise indicated.
[2] Samples purchased in Mali.
[3] Samples purchased at a retail store in Washington, DC. This store usually sells foods originating in Nigeria.

CONCLUSIONS AND RECOMMENDATIONS

Future research should focus on the analysis of additional foods and minerals. Also, more compositional data are needed on foods that have been stored and prepared by standard African techniques. Knowledge of the calcium content in foods and diets where calcium sources are limited should allow a better food selection and estimation of calcium intake, thereby, improving mineral nutrition in Western Africa.

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