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Aluminium contents of some raw and processed Nigerian foods

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Aluminium levels were determined in various raw and processed food items obtained from the Nigerian market. The levels in the processed foods were generally higher than in the raw foods. Raw leafy vegetables contained more aluminium than other raw foods. Levels in Nigerian foods did not differ markedly from those reported for foods in other countries. Copyright © 1996 Elsevier Science Ltd

INTRODUCTION

Aluminium toxicity is well recognised as an important factor in many clinical disorders, the most prominent being Alzheimer's disease (Martyn *et al.*, 1989; Prescott, 1989; Cowburn *et al.*, 1990). It is also associated with the mobilisation of bone phosphate (Lione, 1983; Wills & Savory, 1983), and complications in dialysis dementia and some forms of sclerosis (Spofforth, 1921; Odier, 1925; Crapper *et al.*, 1973; Gruskin, 1988). Even in trace amounts, aluminium is not known to be an essential element in human physiological systems and is usually excreted via faeces and urine (Thines & Harley, 1972).

The main route of aluminium input to humans is through the food chain. Many studies have therefore been directed towards determining the levels of aluminium in various foods in different parts of the world (Underhill *et al.*, 1929; Evenshtein, 1971; Azcue *et al.*, 1988; William & Duffield, 1988; Iskander *et al.*, 1990; Woollard *et al.*, 1990). There are, however, no published records of aluminium levels in various Nigerian foods. This study determines the aluminium contents of many food items consumed in southern Nigeria. The items include raw foods and those which have undergone some degree of processing.

MATERIALS AND METHODS

The food materials were obtained from five different local open markets within the city of Ibadan in the south-west region of Nigeria. The foods are listed in Tables 1 and 2 and constitute components from the main classes of available foods. Each food type was obtained from each of the five markets. Wet foods such as fish, meat, leafy vegetables and tubers were analysed on a wet weight basis after simple air-drying, while normally dry samples were redried in the oven at 70–80°C for 2 h. Water samples for analysis were treated tap water from 11 different sources. All samples were analysed by the colorimetric aluminon method (Sandell, 1959). Solid samples were ground in a mill or chopped up in a blender and then ashed in the muffle furnace at 550–600°C. No ashing aid was added. The ash was dissolved with 5.0 ml 1 M HCl and made up to 50 ml with distilled water. The fatty butter and margarine samples were predigested with concentrated HNO_3/H_2SO_4. The digests were evaporated to dryness and then ashed in the muffle furnace. The water samples were clear and did not require pre-digestion.

All reagents used were of AnalaR grade and sample blanks which incorporated all treatment procedures were used. The regression coefficient for the calibration curve was 0.965. Recovery study was done by spiking some of the samples with various levels of standard aluminium solution. Average recovery was $94.0 \pm 2.3\%$ and this did not vary significantly with the food type spiked.

RESULTS AND DISCUSSION

The aluminium concentrations in the raw and processed foods are respectively listed in Tables 1 and 2. Levels in the raw foods appeared to be generally low and much lower than those for most of the processed food items. The leafy vegetables appeared to have values which were distinctly higher than those of the other raw foods (12.5–78.0 μg/g compared to 0.5–9.7 μg/g). These may be due to a high capacity of these plants to accumulate

Table 1. Concentrations (μg/g) of aluminium in raw foods

Food item	Class	Number	Mean ± SD	Range
Yam	Tuber	5	3.3 ± 0.7	2.7–4.0
Cassava	Tuber	5	4.8 ± 1.0	3.6–6.2
Cocoyam	Tuber	5	3.5 ± 1.0	2.2–4.8
Rice	Cereal	5	1.2 ± 0.4	0.7–1.6
Beans	Bean grain	5	6.0 ± 1.8	3.6–8.6
Maize	Cereal	5	1.2 ± 0.7	0.5–2.2
Soya beans	Bean grain	5	7.8 ± 1.1	6.6–9.6
Beef	Meat	5	1.1 ± 0.5	0.5–1.8
Fish	Fish	5	1.7 ± 1.4	0.5–4.0
Ewedu	Leafy vegetable	5	22.2 ± 3.6	17.5–26.5
Bitter leaf	Leafy vegetable	5	14.4 ± 1.6	12.5–16.7
Tete leaf	Leafy vegetable	5	65.1 ± 9.3	53.4–78.0
Okra seed	Vegetable seed	5	3.2 ± 1.2	1.8–4.8
Melon seed	Vegetable seed	5	2.7 ± 1.3	1.5–4.5
Onions	Vegetable spice	5	2.1 ± 0.7	1.4–3.1
Pepper	Vegetable spice	5	10.7 ± 1.2	8.9–11.7
Mango	Fruit	5	1.8 ± 0.5	1.1–2.2
Orange	Fruit	5	3.0 ± 0.8	2.2–4.3
Pineapple	Fruit	5	1.9 ± 1.1	0.9–3.1
Banana	Fruit	5	7.5 ± 1.3	6.6–9.7

Table 2. Concentrations (μg/g) of aluminium in processed foods

Food type	Description	Number	Mean ± SD	Range
Garri	Fried cassava flour	5	16.7 ± 3.3	11.3–20.2
Elubo	Yam flour	5	18.1 ± 2.9	16.0–22.5
Lafun	Dried cassava flour	6	15.0 ± 2.6	9.8–16.3
Pap	Corn porridge	5	6.5 ± 0.9	5.2–7.3
Corn flakes	Corn flakes	5	21.3 ± 5.1	13.7–25.5
Akara	Fried bean cake	6	8.5 ± 1.5	6.0–9.7
Moinmoin	Steamed bean pudding	6	10.3 ± 2.5	6.0–13.3
Bread	Wheat bread	5	16.8 ± 3.2	13.5–22.0
Sardine	Canned fish	5	2.7 ± 0.9	1.8–3.8
Jam	Fruit/sugar jam	7	17.6 ± 5.2	13.5–26.0
Butter	Butter (vegetable)	5	5.1 ± 1.8	2.0–6.5
Margarine	Margarine (,)	5	23.4 ± 1.5	21.4–25.0
Cheese	Milk cheese	6	2.4 ± 1.4	1.3–5.2
Milk powder	Powdered milk	6	3.9 ± 1.5	2.3–6.3
Fruit juice[a]	Packed fruit drink	6	0.6 ± 0.4	0.3–1.3
Soya milk[a]	Soya bean milk	5	9.5 ± 0.8	9.0–10.7
Malt drink[a]	Malted soft drink	7	0.4 ± 0.2	0.2–0.7
Cocoa drink	Packed cocoa beverage	5	4.8 ± 1.5	3.3–7.3
Tomato puree	Canned tomato paste	6	21.2 ± 3.7	17.8–26.7
Curry powder	Curry spice powder	5	4.0 ± 1.5	2.5–6.0
Maggi cube	Meat extract spice	5	39.7 ± 6.8	14.5–4.3
Water[a]	Treated tap water	10	0.3 ± 0.1	0.2–0.5

[a]Concentrations in μg/ml.

the metal in their leaf tissues, as well as the larger exposure of leaf surface areas to atmospheric dust. The latter reason may also account for the observed enhanced levels in pepper (8.9–11.7 μg/g).

The processed foods had slightly enhanced aluminium levels in comparison with the corresponding raw foods from which they were obtained, e.g. Yam/Yam flour (3.3 ± 0.7/18.1 ± 2.9) i.e. mean ± standard deviation; Cassava/Garri (fried cassava flour)/Lafun (dried cassava flour) (4.8 ± 1.0/16.7 ± 3.3/15.0 ± 2.6); Beans/Akara (fried bean cake)/Moinmoin (steamed bean pudding) (6.0 ± 1.8/8.5 ± 1.5/10.3 ± 2.5). The higher values in the processed samples may have arisen from contamination during handling, exposure and processing. The processing steps mainly involve grinding in steel mills, roasting, boiling and frying in steel- or aluminium-ware from which such contamination may have resulted.

Literature values of aluminium contents of some foods in other parts of the world are listed in Table 3. These show that the levels in Nigerian foods are not higher than average values obtained in foods elsewhere. Level in lettuce, a leafy vegetable, was noted to be higher than in most other foods in Brazil. This com-

Table 3. Levels (μg/g) of aluminium in foods in other countries

Food type	Country	Mean ± SD	Range
Bread	Egypt[b]	—	18.1–224
Wheat flour	Egypt[b]	16.9	—
Corn flour	Egypt[b]	91.4	—
Tomatoes	Brazil[c]	1.4 ± 1.0	0.3–3.2
Cow's milk[a]	Brazil[c]	1.8 ± 3.1	N.D–8.9
Fish body	Brazil[c]	14 ± 10	6.7–21.2
Lettuce	Brazil[c]	26.0 ± 9.3	9.9–40.0
Apple juice[a]	UK[d]	9.4	—
Wine[a]	UK[d]	—	1.5–3.0
Beer	USSR[e]	5.5	—
Beef	USA[f]	5.0	—
Sweet corn	USA[f]	2.6	—
Milk[a]	USA[f]	15.4	—
Onions	USA[f]	43.1	—
Oranges	USA[f]	0.9	—
Potatoes	USA[f]	9.7	—

[a]Concentrations in μg/ml.
[b]Iskander *et al.* (1990).
[c]Azcue *et al.* (1988).
[d]William & Duffield (1988).
[e]Evenshtein (1971).
[f]Underhill *et al.* (1929).

pares with the observation of high values in raw leafy vegetables in this study. No specific critical limits of aluminium contents of foods have been defined in most countries' food legislations. The values reported here for Nigerian foods cannot therefore be categorically described as harmful or otherwise. The results, however, provide useful data on current levels in the various food types.

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