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Titrimetric Determination of Calcium Content of Some Staple Foodstuffs in North-Central Nigeria

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Abstract

This work investigates the calcium content of one hundred and sixty-two samples of locally produced and commonly consumed food items collected from six towns in North-Central Nigeria. The samples were analysed in triplicates using the method of EDTA titration. The highest mean level of calcium was obtained in melon (220 mg/100g) followed by water leaf (173 mg/100g), then white beans (152 mg/100g), okro(118 mg/100g), gari (106 mg/100g), maize (49 mg/100g), yam (42 mg/100g), rice (35 mg/100g) and (25 mg/100g). These results were compared with values reported in the literature.

Keywords: calcium, staple foods, EDTA titration, gari, water leaf, North-central Nigeria

1. Introduction

Foods in the form of carbohydrates, fats and protein supply the human body with the required energy for metabolic processes. Foods also provide the body with substances such as amino acids, vitamins and minerals, all of which are required for growth , maintenance of cells and tissues. Minerals are needed by the human body in relatively small amounts, hence they are classified as micronutrients (Norhaiz and Nor, 2009).

Calcium, one of the essential minerals, is the most abundant mineral constituent of the human body, making up about 1-2% of the entire body weight of an average adult human (TGMF, 2013). It is the most important component of the skeletal system (Saini and Davar 2012); the most critical nutrient to skeletal health. In addition to the vital roles it plays in the skeletal system where it helps in the development and maintenance of strong bones and teeth, calcium contributes to the effectiveness of various biological processes including mitosis, blood coagulation , cell adhesiveness, muscle contraction and glandular secretion (Miller and Anderson, 1999, UMMC, 2013). It is also important in the effective functioning of the heart and nerves, and for managing acid/base balance in the blood stream (UMMC, 2013). Deficiency of calcium in humans especially adults results in Osteoporosis, a condition of low bone mineral density, in which the bones become porous, fragile, and more bone to fracture in adults. Children should also take enough calcium as they are growing and forming bones. Nearly 40% total adult bone mass is established between ages 10 and 15 years. Inadequate intake of dietary calcium from food can also lead to hypocalcemia, which manifests in the form of muscle cramps, convulsion, numbness and tingling in the fingers (Dawson-Hughes et al., 2009).

It has been observed that one out of every two women over the age of 45 years is afflicted by osteoporosis (Saini and Davar, 2012). It is also a serious public health problem for over 10 million adults above the age of 50 years in the United States of America (National Institute of Health, Office of Dietary Supplements, 2013). Excess calcium in the body can have adverse effect on health as it can cause constipation, and high risk of kidney stone and prostrate cancer in adults. It may also interfere with the body's ability to absorb iron and zinc (NHI, March 2013). Getting enough calcium in the body is helpful in preventing premenstrual syndrome and high blood pressure, lowering of cholesterol and in treating rickets in children (UMMC, 2013). Table 1 shows the recommended amount and safe limit of calcium per day by people of different age groups (UMMC, March 2013).

The best way to get calcium into the body system is through food – natural or fortified. Calcium is found in many foods but in varying amounts (NIH, March 2013). Depending on the type of food, humans absorb up to 30% of the calcium in food (Food and Nutrition Board, 2010). This study was, therefore, conducted to determine titrimetrically the levels of calcium in commonly consumed foods in six selected towns, some of them more than 400 km apart in north-central region of Nigeria. This was to contribute to the knowledge about nutrient composition of foods which, according to Scrimshaw (1994), is very important in areas such as: health assessment, nutrition education, epidemiological research on relationship between diet and diseases, food regulation and consumer protection.

2. Materials and methods

2.1 Collection of Samples

Samples of nine different food items (Local rice, white beans, gari, melon, water leaf, dry maize, yam, banana and okro) were bought in triplicates from local farmers in six towns (New Bussa, Ajasepo, Pategi, Kaiama, Ilorin and Okene) in the North-Central geo-political zone of Nigeria. The samples were separately kept in clean labeled polythene bags immediately on collection to avoid cross-contamination during transportation to the laboratory, where they were stored in the refrigerator. The samples were digested and analyzed in less than one week from the time of collection.

2.2 Digestion of Samples

Since all the samples were obtained in solid form, they were digested using a mixture of concentrated nitric acid, sulphuric acid and hydrogen peroxide. This is to render their mineral contents into solution so as to be amenable for the required chemical analysis.

An accurately weighed 5.000g of the edible protion of each of the food stuffs was put in a heat-resistant beaker where 8 mL of concentrated sulphuric acid and 10 mL of concentrated nitric acid were added. The beaker was then placed on a hot plate and warmed cautiously until the reaction subsided. It was then heated vigorously until the solution begins to darken owing to incipient charring.

To avoid such charring, a 2 cm^3 aliqout of concentrated nitric acid was constantly added at any time the solution began to darken. This treatment was continued until the solution stopped to darken on prolonged heating . At this point, the solution was allowed to cool and diluted with 10 mL of doubly-distilled water and boiled to fuming. This dilution and boiling to fuming process was repeated twice again but with 5cm^3 of doubly-distilled water.

At this point, the persistent colour(s) of the solution are cleared by the addition of about 2-4 mL of hydrogen peroxide with drops of Nitric acid again. The solution was heated to fuming state each time hydrogen peroxide was added until the residue was colourless or no further reduction of pale yellow colour was obtained. The solution was cooled with about 10 mL of distilled water and evaporated to fuming again. This continued until there was no more fuming; then the solution was made up to mark in 100 mL volumetric flask.

2.3 Determination of Calcium by titrimetry

A 25.0 mL aliquot of each digest was pipetted into a beaker and 1M NaOH solution was added to adjust the pH to 12-13. Two drops of solochrome dark blue was then added and immediately titrated against a 0.01M EDTA solution to the blue end-point. For every determination and evaluation, a standard curve of mass of calcium (mg) versus amount of EDTA (millimoles) was plotted.

3. Results and Discussion

The range of calcium content (mg/100g) of three samples each of the nine staple foodstuff (maize, banana, gari, local rice, okro, melon, white beans, yam and water leaf) analysed in triplicates are given in Table 1. The lowest calcium concentration in maize (13 mg/100 g) was observed in a sample from Pategi, while the highest (96 mg/100 g) was recorded in an Ilorin sample. For banana and gari foodstuff, the highest calcium contents were recorded in Ajasepo (40 mg/100 g) and Kaiama (176 mg/100 g) samples respectively; with the lowest values again from Pategi (12mg/100g and 42mg/100g respectively). Melon had the highest calcium concentration (292 mg/100 g) which was determined in a sample from Ajasepo. The lowest calcium content of melon was 132 mg/100 g, obtained from a New Bussa sample. This is, however, higher than the highest levels of calcium contained in any maize, banana, rice and yam sample (Table 2).

Figures 1 – 6 show the mean calcium contents (mg/100 g) of three samples (each of which was analysed in triplicates) of the nine different food items in each of the sampling locations (Ajasepo, Ilorin, Kaiama, Pategi, Okene and New Bussa). That is, each data point on the chart is a mean of nine results from three samples analysed in triplicates. The average calcium contents of staple food samples obtained from Ajasepo are shown in Figure 1. It is revealed that melon had the highest calcium concentration (274 mg/100 g), followed by water leaf (200 mg/100 g) and okro (105 mg/ 100g) while banana had the least content (32 mg/100 g)..

In Ilorin, Okene and Kaiama, calcium contents were highest in melon (Figures 2, 3 and 4). The concentrations were 267, 264 and 196 mg/100 g respectively. The order of calcium contents for Ilorin was: melon > okro > water leaf > beans > gari > maize > yam > rice > banana (Figure 2). For Okene and Kaiama, the order of calcium levels in food samples were: melon > okro > water leaf > beans > gari > yam > rice > maize > banana (Figure 3) and melon > beans > gari > water leaf > okro > maize > yam > banana > rice (Figure 4). The only sampling location where melon did not have the highest calcium content was New Bussa (Figure 5). In these samples,

beans had the highest average calcium concentration (169 mg/100 g) followed by melon, then water leaf, gari and yam. The lowest level of calcium was in maize (18 mg/100 g).

The results for Pategi food samples are depicted in figure 6. It shows that the lowest calcium contents were from maize and banana (14 mg/100 g), while melon had the highest (174 mg/100 g). Calcium contents of foodstuff samples from Pategi were generally lower than for other locations (Figure 7). In all the samples from the six sampling areas, lower levels of calcium were generally recorded in rice, banana, yam and maize while melon , water leaf , okro and beans generally contained relatively high amount of calcium (Figure 7). Figures 7 and 8 also show the calcium content of the foodstuff samples vis-à-vis the six sampling locations. The order of the magnitude of calcium concentration are given as follows: Maize : Ajasepo > Ilorin > Kaiama > Okene > New Bussa > Pategi; Banana : Ajasepo > Kaiama > New Bussa > Okene > Ilorin > Pategi; Gari : Kaiama > Okene > Ajasepo > Ilorin > New Bussa > Pategi; Rice : Ajasepo > Okene > Ilorin > Kaiama > New Bussa > Pategi; Okro : Okene > Ilorin > Kaiama > Ajasepo > Pategi > New Bussa; Melon : Ajasepo > Ilorin > Okene > Kaiama > Pategi > New Bussa; Beans : Kaiama > Okene > New Bussa > Ilorin > Pategi > Ajasepo; Yam : Okene > Ajasepo > Ilorin > Kaiama > New Bussa > Pategi and Water leaf : Ajasepo > Okene > Ilorin > Kaiama > New Bussa > Pategi.

The order shows that out of the nine food items studied, five (maize, banana, rice, melon and water leaf) had their highest concentrations recorded in Ajasepo, while gari and beans were from Kaiama, and okro and yam from Okene.

What combination of the staple foods could yield a good calcium diet is shown in figure 8. For example, a meal comprising of yam (either in the form of cooked or pounded yam) with a soup prepared from water leaf and melon will provide a satisfactory level of calcium content. Similarly, other good combinations are gari and either water leaf with melon soup or bean soup, and gari with bean cake or moin-moin. However, if a diet of low calcium content is desired, as is the case with people suffering from or have history of kidney stone, a meal comprising of local rice, yam and banana is adequate.

Figure 9 shows the average concentration of calcium in all the twenty seven foodstuff samples per sample location. It is clear from the figure that Okene had the highest overall average calcium content (127.1 mg/100 g) followed by Ilorin (120.4 mg/100 g), then Ajasepo (110.9 mg/100 g). The lowest overall average calcium concentration was for Pategi (65.6 mg/100 g).

Calcium concentrations determined in the various food stuff in this study are compared with values reported in the literature (Table 3). The average calcium content of the food items studied in this work were higher than the values reported by Saini and Davar (2012), and Gapolen et al. (2012). For example, the mean concentration of maize in this study was 49 mg/100 g, which is higher than 11.46 and 10 mg/100g reported respectively by the authors. Also, the mean calcium content of rice obtained in this work (35.0 mg/100g) is lower than 51.1 mg/100g reported by Tee et al,.(1989) using potassium permanganate titration methods. The difference in calcium concentration determined in the same food stuff but of different sampling areas, in this study, and values reported by other researchers from different regions of the world could be attributed to several factors. These include differences in the species cultivated, farming methods and methods of chemical analysis (Nordeide et al; 1996 and Mayer, 1997), as well as the geochemical nature of the soils on which the crops were cultivated.

5. Conclusion

Calcium contents of a total of one hundred and sixty-two samples of nine staple food items from six towns in the north-central region of Nigeria were determined. The highest calcium concentration was found in melon followed by water leaf and beans and the lowest content was in banana. Putting together all the samples, Okene had the highest level of calcium determined, then Ilorin; while the lowest was in Pategi. The average calcium concentration determined in this study was higher than the values reported by some other workers elsewhere.

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Table 1: Recommended amount and safe limit of calcium per day by different people

Age group	**Recommended amount (mg)**	**Upper Safe Limit (g)**
Birth to 6 months	200	1,000
Infants (7-12 months)	260	1,500
Children (1-3 years)	700	
Children (4-8 years)	1,000	2,500
Children (9-18 years)	1,300	3,000
Adults (19-50 years)	1,000	2,500
Adult men (51-70 years)	1,200	2,000
Adult women (51-70 years)	1,200	2,000
Pregnant and breastfeeding teens	1,300	3,000
Pregnant and breastfeeding adults	1,000	2,500

Table 2 : Calcium content (mg/100g) of some staple foods in North-Central Nigeria

Food Stuff	Sampling locations / Calcium content (mg/100g)					
	Ajasepo	Ilorin	Kaiama	Pategi	Okene	New Bussa
Maize	84-92	84-96	44-48	13-16	28-40	15-20
Banana	24-40	20-25	28-36	12-16	24-28	24-32
Gari	92-96	84-92	160-176	42-48	144-160	70-84
Local rice	48-64	28-40	24-28	16-24	48-52	20-25
Okro	102-109	176-184	104-108	84-92	168-220	30-37
Melon	264-292	264-272	192-200	164-180	260-272	132-152
White beans	84-96	164-180	184-196	102-115	176-192	164-180
Yam	48-64	44-48	44-48	12-16	48-64	24-40
Water leaf	192-212	164-192	152-164	106-108	192-200	124-136

Table 3 : Calcium content (mg/100g) of food items in this study compared with some reported values

Foodstuff	Calcium content of foods (mg/100g)		
	This work	Saini and Davar	Gopalan et al
Maize	49	11.46	10
Banana	25	6.53	17
Gari	106	-	-
Rice	35	7.9	10
Okro	118	-	-
Melon	220	-	-
Beans	152	40.3	50
Yam	42	-	-
Water leaf	173	-	-

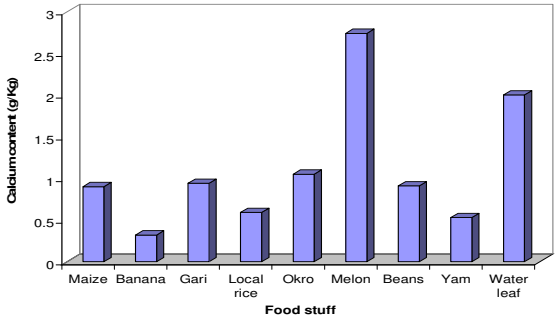

Figure 1: Calcium content of staple food items from Ajasepo

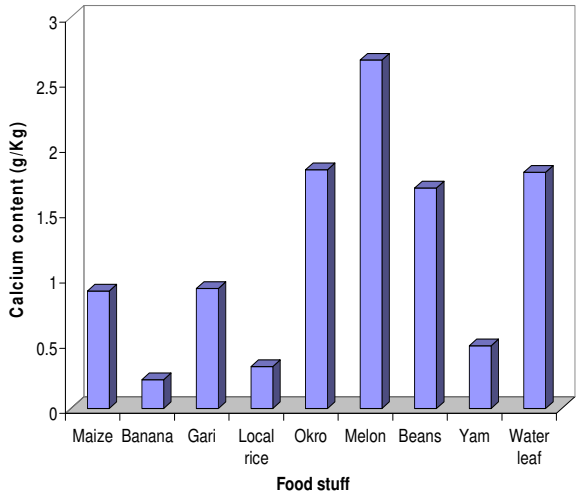

Figure 2: Calcium content of staple food items from Ilorin

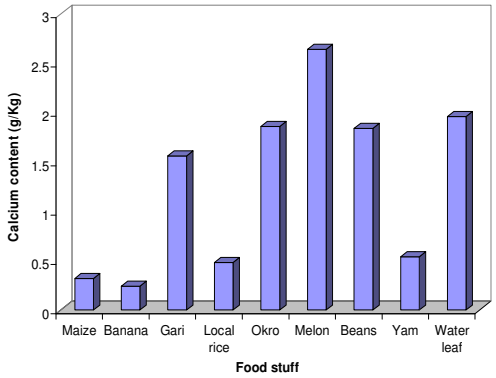

Figure 3: Calcium content of staple food items from Okene

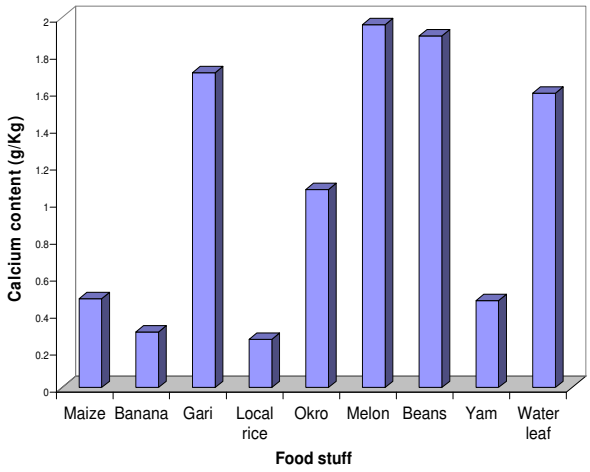

Figure 4: Calcium content of staple food items from Kaiama

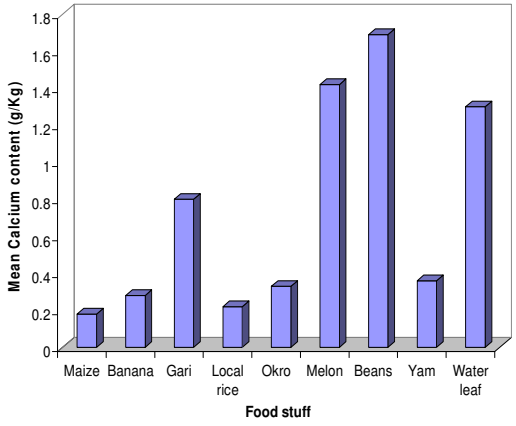

Figure 5: Calcium content of staple food items from New Bussa

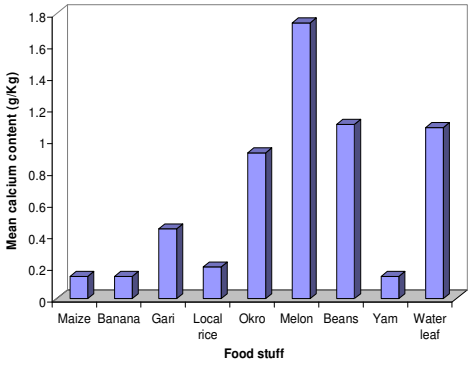

Figure 6: Calcium content of staple food items from Pategi

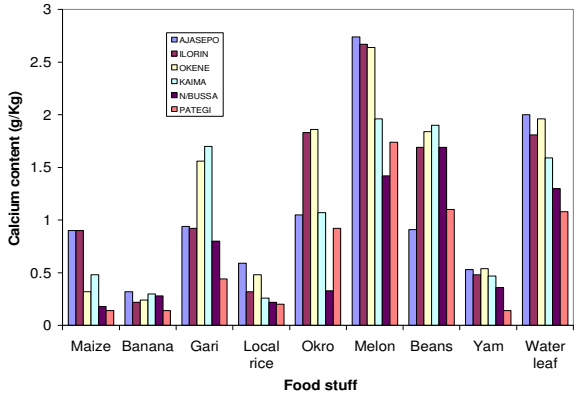

Figure 7: Calcium content of staple food items from all the sampling locations

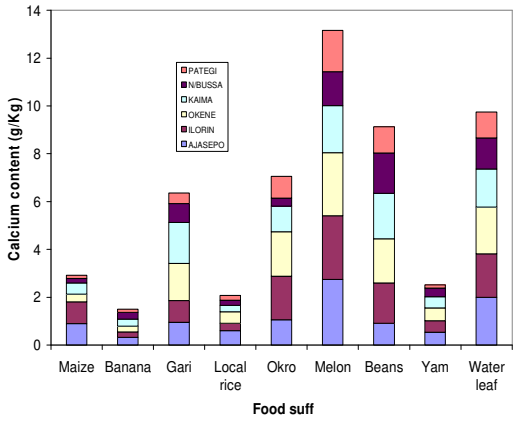

Figure 8: Calcium content of staple food items vis-à-vis sampling locations

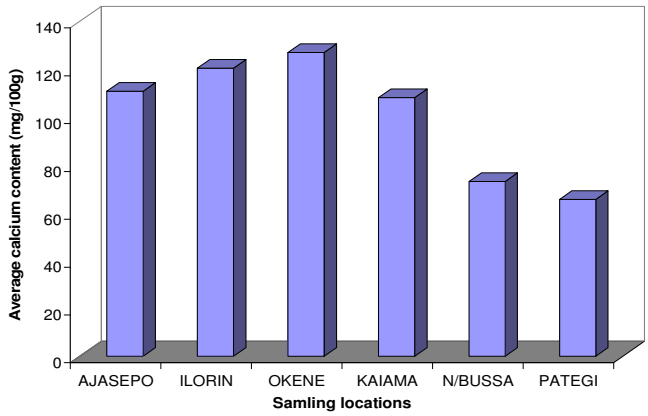

Figure 9: Average calcium concentration of all food samples per sampling location

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