Available online at www.elixirpublishers.com (Elixir International Journal)

Food Science

Elixir Food Science 46 (2012) 8479-8482

ISSN: 2229-712X

Oxalate, Cyanogenic Glycocide, iron and zinc contents of selected commercial brand baby food on the Ghanaian market

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ARTICLE INFO

Article history:
Received: 12 March 2012;
Received in revised form:
15 May 2012;
Accepted: 24 May 2012;

Keywords
Anti-nutrition,
Oxalate,
Cyanogenic glycoside,
Baby food,
Mineral.

ABSTRACT

Food substances worthy of consumption have nutritive values of great dietary effect which in the first place attract people to eat them. As they contain the required nutrients, they also may contain some anti-nutritive substances which may or may not be in trace amounts. In this study sixteen commercial baby foods, comprising five different brands, available on the Ghanaian market have been analysed for their anti-nutrients content (oxalate and cyanogenic glycoside) adopting the method of Andrew and Visser (1951) and the Official Methods, (AOAC 915.03, 17th Ed) together with their mineral Fe and Zn content using the method of Hernandez *et al.* (2004) with modification. The total oxalate concentration levels in the 16 selected cereal brand baby food products ranged from 0.08 to 0.27 mg/g. The HCN concentration levels in the 16 selected cereal brand baby food products ranged from 0.07 to 0.36 mg/g. The concentration levels of Fe and Zn in the brand samples ranged between 24.12-220.76 mg/kg and 0.82-33.88 mg/kg respectively. The concentration levels ranged between 1.67-12.88 mg of total oxalate per serving for BFN-3 (rice based product) and BFB-2 (milk and honey based product) respectively whilst that of cyanogenic glycoside is 1.96-17.06 mg per serving for BFF-1(Lactea based product) and BFN-1 (fiber based product) respectively. Fe concentration levels ranging between 0.68-4.41mg per serving for BFC-3 (fruit and wheat based product) and BFN-4 (oat based product) respectively whilst that of Zn is 0.01- 1.15 mg per serving for BFBN-3 (muesli with apple) and BFN-3 (rice based product). Fourteen of the 16 cereal brand baby foods contained less than 10 mg oxalate per serving, defined as a low oxalate food. Differences in anti-nutritional factors within the brands were observed. The results of the analysis suggest that oat based product, appear to offer better nutritional value partly due to its low ANF coupled with its relatively high mineral iron content.

Introduction

Malnutrition is a major health problem in developing countries and contributes to infant mortality, poor physical and intellectual development of infants, as well as lowered resistance to disease and consequently stifles development (Amankwah et al, 2009).

Food substances worthy of consumption have nutritive values of great dietary effect which in the first place attract people to eat them. On the other hand, these same food substances may contain antinutritive substances (Massey et al, 2001). It is well known that plants generally contain antinutrients acquired from fertilizer and pesticides and several naturally-occurring chemicals (IgileG O, 1996). Cereals and baby foods are no exception to these characteristics. As they contain the required nutrients, they also may contain some anti-nutritive substances which may or may not be in trace amounts. Some of these chemicals are known as ''secondary metabolites'' and they have been shown to be highly biologically active (Zenk H. M, 1991). They include saponins, tannins, flavonoids, alkaloids, trypsin (protease) inhibitors, oxalates, phytates, haemagluttinins (lectins), Cyanogenic Glycocide, cardiac glycosides, coumarins and gossypol. The list is inexhaustible. Some of these plant chemicals have been shown to be deleterious to health or evidently advantageous to human and animal health if consumed at appropriate amounts (Kersten et al, 19191; Sugano et al, 1993). The anti-nutritional factors (ANFs) may be defined as those substances generated in natural food stuffs by the normal metabolism of species and by different mechanisms (for example inactivation of some nutrients, diminution of the digestive process, or metabolic utilization of feed) which exert effects contrary to optimum nutrition (Kumar R,1992). Oxalate is a concern because high oxalate diets can increase the risk of renal calcium absorption. Two general reviews of plant oxalates and their biochemistry and toxicity have been contributed by Curham as well as by Fasset (Curham, 1999; Fasset, 1973). It has been claimed that oxalate accumulates as calcium oxalate in cereal seeds (Webb and Arnott, 1982). Literature has shown that foods which contain these oxalates produce chronic effects which include: the deposition of calcium oxalate crytals in the kidney known as nephrolithisis (kidney stones) (Concon, 1988; Holmes and Kennedy, 2000) and the occurrence of stones in the urinary tracts (Parker, 1980).

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Hydrocyanic acid is found to inhibit the activity of vitamin K dependent carboxylase of the liver (Ene-Obong, 2001). Cyanide is able to inhibit cellular oxidation by combining with the catalytic ion of cytochrome oxidate leading to elimination of the active unit concerned with transfer of electrons to molecular oxygen (Demetz et al, 1982).

Minerals, classified as micronutrients are needed by our body in small amounts. Deficiency in minerals, however, can have a major impact on health such as anemia and osteoporosis that commonly occur in both developed and developing countries. This study focused on iron (Fe) and zinc (Zn) only.

Iron is a very important nutrient for growing children. It is used to make haemoglobim which is necessary for the transport, storage and use of oxygen throughout the body. All babies are born with a supply of iron, which takes them through the first six months of life (http://www.babyfoodchart.com). After that, iron must be obtained through the diet. Children may develop iron-defiency anaemia if they do not obtain an adequate supply of iron in their diet. The absorption of iron is affected by factors such as intake of oxalates and phytates which can bind with iron in plant sources.

Zinc is essential for normal growth and development, a healthy reproductive system and fertility, healthy foetal development, and a strong immune system. A deficiency of zinc can lead to: increase risk of infections, impaired sense of taste and smell, night blindness, retarded growth and development during infancy. Excessive absorption of zinc may suppress iron absorption (http://www.babyfoodchart.com).

It is known that plants generally contain anti-nutrients acquired from fertilizer and pesticides and several naturally-occurring chemicals (Amankwah et al, 2009). In recent years, there has been great interest to analyze infant formulas. There are no published data on anti nutritional factors in baby foods marketed in Ghana. The objective of this work is to determine some of these anti nutritional factors that affect the absorption of some of the essential nutrients in the foods that are fed to infants and estimate the amount of iron and zinc therein.

Materials and methods

Materials

Sixteen different products from among six brands of cereal baby food were purchased from three supermarkets in the capital city, Accra. Among the brands were Beechnut, Bledina, Cerelac, Nutrilon, Purity, and Farinha.

Methods

Preparation of Samples

Twenty gramme each of the brand sample were taken and grinded using laboratory miller (FRITSCH Pulverisette 2, Germany) at the Ghana Research Reactor 1 Centre of the Ghana Atomic Energy Commission. It was then kept in Ziploc polyethylene bags for subsequent analysis.

Determination of oxalate and cyanogenic glycoside

All reagents used were of analytical grade. The oxalate content of the samples was determined adopting the method of Andrew and Visser (Andrew and Visser 1951). Five grammes each of finely powdered samples were weighed out and each digested with 150 ml of 3 M HCl for about 30 minutes. The solution was cooled, filtered and the filtrate made up to 100 ml using de-ionized water. The pH of the resulting solution was adjusted to 7.0 using aqueous ammonia. A solution of saturated $CaCl_2$ was added to double the volume. A slight white colouration was observed and this indicated the presence of low concentration of oxalate ion. The solution was then kept overnight in a water bath (KOTTERMANN-LABORTECHNIK, W-Germany) at a temperature of 60 °C. It was centrifuged (Spectra Merlin, Great Britain) using Falcon BD tubes and the precipitate collected in the test tube by decanting the supernatant liquid. Finally, the precipitate was dissolved in 10 ml of 0.5 M H_2SO_4 and the solution made up to 50 ml using H_2SO_4. The solution was left overnight to remove the white precipitate formed completely. The resulting filtrate was transferred quantitatively into a 250 ml Erlenmeyer flask. Then a 25 cm^3 of the solution was pipetted into a conical flask, and heated and maintained at 70 °C using Stuart Scientific Magnetic Stirrer and titrated with 0.02 M $KMnO_4$ until a permanent pink colouration was observed. The titration was repeated two times and the average value was taken. The equation for the redox reaction is presented below:

$$2MnO_4^{-} + 5C_2O_4^{2-} + 16H^{+} \longrightarrow 2Mn^{2+} + 10CO_2 + 8H_2O$$

The Cyanogenic Glycocide content of the samples was determined using the alkaline titration method prescribed by the Association of Official Analytical Chemist (AOAC 915.03) (AOAC, 2000).

A recovery study was carried out where 20 mg sodium oxalate (Merck, Germany) was added to triplicate 5g samples of the finely ground samples. One set of recovery analysis was carried out on finely ground samples while the other analysis was carried out for standardization. The mean recovery of oxalate ± SD was 95.87% and 98.83% for the standardization.

Determination of iron and zinc

The Fe and Zn contents of the brand baby food samples were measured by atomic absorption spectrophotometry (VARIAN AA240FS, USA) after a microwave assisted digestion according to the method of Hernandez with modification (Hernandez et al, 2004). Hydrogen peroxide (MERCK, Germany) and Nitric acid (Sigma-Aldrich, Germany) were used for the digestion.

0.5 g of pulverized brand samples were weighed into Teflon beakers and 6 ml HNO_3 and 1 ml H_2O_2 added. The Teflon beakers were placed in the bomb and closed tightly. The bomb was placed at the center of a microwave oven (ETHOS 900 Microwave, Millestone) and digested for 26 min at full power. The digestate was then used to determine Fe (λ=248.3nm) and Zn (λ=213.9nm) using air –acetylene gas mixture. Standard stock solution of iron and zinc were prepared from AAS grade chemicals (Spectrascan, Teknolab AB, Sweden) by appropriate dilution.

Results

The results of the laboratory analysis of total Oxalate, Cyanogenic Glycocide (as HCN), Fe and Zn content in the cereal brand baby food are presented in Table 1. The variations of these parameters in the brand samples are also presented in Figure 1. The total oxalate concentration levels in the 16 selected cereal baby food products ranged from 0.08 to 0.27 mg/g. The HCN concentration levels in the 16 selected cereal baby food products ranged from 0.07 to 0.36 mg/g. The concentration levels of Fe and Zn in the brand samples ranged between 24.12-220.76 mg/kg and 0.82-33.88 mg/kg respectively. Major variations in both anti-nutrient and minerals content within the brands were observed.

Discussions

The results of the laboratory analysis of the total Oxalate and Cyanogenic Glycocide (as HCN) content in the cereal baby foods are presented in Table 1 and Figure 1. The total oxalate concentration in the 16 selected cereal baby foods ranged from

0.08 to 0.27mg/g. This shows a wide range of oxalate values in these commercial cereal baby foods. The amount of oxalate per serving ranged from 1.67 to 12.88 mg oxalate per serving, indicating that some of these products are considered high oxalate foods. Fourteen of the 16 cereal baby foods contained less than 10 mg oxalate per serving. The brand sample BFB-1 which is a fruit based product, contained the lowest oxalate value of 0.08mg/g. Food containing greater than 10 mg of oxalate per serving are considered high oxalate foods (Chicago Dietetic Association, 2000). Thus 12.5% of the samples could be considered as high oxalate food.

The HCN concentration levels in the 16 selected cereal brand baby food products ranged from 0.07 to 0.36 mg/g. This demonstrates again a wide range of hydrogen cyanide content in these commercial cereal baby foods. Fifty per cent of the cereal baby foods contained more than 10 mg hydrogen cyanide per serving. With the exception of BFB-2, BFB-4 and BFF-1, the hydrogen cyanide content was always higher than the oxalate Figure 1. There appears not to be any relationship between the concentration levels of oxalate and HCN (r^2=0.12) in the brand samples Figure 2.

Within the BFBN samples, BFBN-2 contained higher levels of both HCN & Oxalate compared to the BFBN-3 and BFBN-1. In the other oats based food, BFN-4, the total oxalate and HCN content was comparably low. BFN-4 cereal therefore seems not to contribute appreciably to the total oxalate and HCN of baby cereal foods.

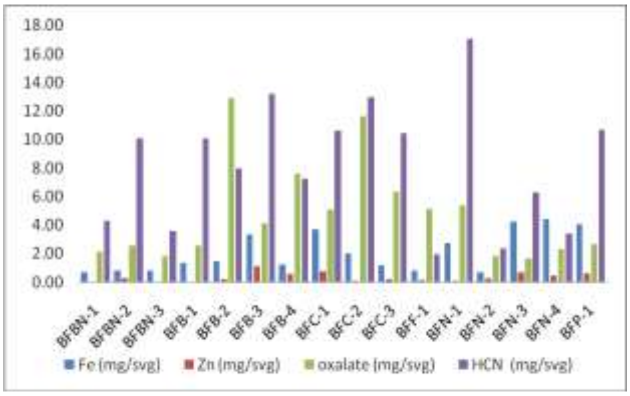

Figure 1: Oxalate, HCN, Fe and Zn concentration per servings in brand samples

Brand sample BFCs containing fruits as mixtures or parts such as BFP-1, BFN-1 exhibited comparably higher levels of both HCN & Oxalate. At present it seems that the additional fruits into the cereal baby food are responsible for the ANF especially the HCN. However further work would have to be done to confirm this assertion.

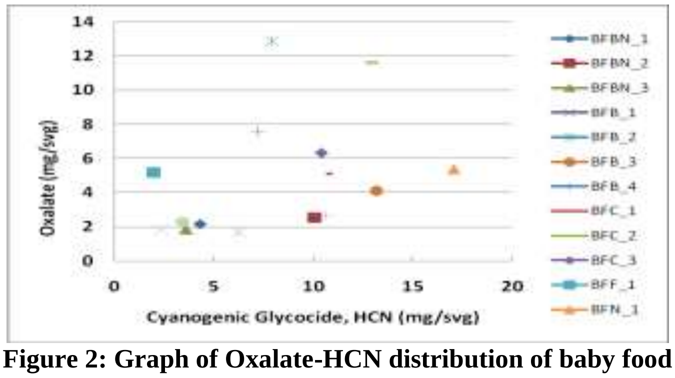

Figure 2: Graph of Oxalate-HCN distribution of baby food samples per serving

Four products of BFB-1to 4 exhibited concentration range of 2.56-12.88 and 7.22-13.17 mg/serving ox total oxalate and HCN respectively. The highest level of 12.88 mg oxalate/serving was recorded for BFB-2 whilst the 13.17 mg HCN/serving was recorded for BFB-3. Although the concentrations of HCN are generally higher than the total oxalate, in the BFB-3 the concentration of HCN was about three times whereas in the BFB-1 it is about four times higher. No reason could be assign to this observation at present. Again, whereas the BFB-4 exhibited comparable amount of total oxalate and HCN, the BFB-2 on the contrary contained higher concentration of oxalate than HCN. BFB-2 is thus considered as a high oxalate food.

Three products of BFC-1to 3 brand exhibited concentration ranges of 5.10-11.62 and 10.42-12.96 mg/serving of oxalate and HCN respectively. The BFC-1 product contained twice as much HCN as oxalate and the BFC-2 product revealed comparable levels of both oxalate and HCN. The BFC-2 brand product is therefore considered as a high oxalate food.

Four products of the BFN-1to 4 brand exhibited concentration range of 1.67-5.37 and 2.36-17.06 mg/serving total oxalate and HCN respectively. The BFN-1 product contains the highest levels of HCN among the brand product and also all the products analyzed in this work.

Although literature is not available for similar work, other researchesr have reported values of oxalates levels in bread samples in the range 0.22 - 0.35 mg/g and 0.17 - 0.48 mg/g for wheat flour samples (Obot et al, 2008). Similarly this author reportedly found hydrocyanic acid content in bread and flour samples respectively to be in the range 0.04 to0.0 6 mg/g and 0.04 to 0.11 mg/g. The result shows low hydrocyanic acid content compared to this study (0.07-0.36mg/g). Another researcher has reported the hydrocyanic acid content of Wheat Triticum spp to be 0.82 mg/g (Chakraborty and Eka, 1978) which is much higher than those obtain in this study. The processing steps involved in the manufacturing of raw materials into the finished product might be responsible and therefore account for the observation.

Different processing methods have different effects on food anti-nutrient. For example, 17% of total oxalate in spinach is reduced by blanching for 15 min (Bakr and Gawish, 1997), whereas baking oca tubers (New Zealand sweet potatoes) may increase oxalate by 79% (Sangketkit et al, 2001).

Oxalic acid and oxalates occur naturally in plants but they have little or no useful effect on human health as high levels in diets lead to irritation of the tissues; the digestive system, particularly the stomach and kidney (Hodkinson , 1977).

Elemental analysis of the brand samples were done in order to ascertain their minor mineral (micronutrient) profile. Iron, zinc, manganese and copper showed their presence though only the first two are presented in this paper. Cadmium, lead, chromium and nickel were below the detection limits of the instrument (<0.001).

The amount of the two minor minerals available per serving is presented in Figure 1. With mineral Fe concentration levels ranging between 0.68-4.41mg per serving for BFC-3 (fruit and wheat based product) and BFN-4 (oat based product) respectively whilst that of Zn is 0.01- 1.15 mg per serving for BFBN-3 (muesli with apple) and BFN-3 (rice based product).

The results of the analysis suggest that BFN-4, an oat based product, appear to offer better nutritional value. This is partly due to its low ANF coupled with its relatively high mineral iron content. Two meals of BFN-4 a day will not only meet the recommended daily allowance of Fe for children less than three years (Institute of Medicine, 2001) but chances are that the mineral will be bioavailable.

Conclusion

The results of the analyses show an average of 4.73 mg oxalate and 8.26 mg HCN per serving respectively. This suggests that the consumption of these cereal baby food items may not pose risk to public health. The consumption of BFB-2 and BFC-2 which are 'milk and honey' and wheat based products, however, should be reduced to avoid the probable formation of kidney stone due to its high oxalate content. Oat based products tended to offer a better balance between ANF and mineral bioavailability.

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Table 1: Total Oxalate, Cyanogenic glycoside (as HCN), Iron (Fe) and Zinc (Zn) content in brand baby food

Brand	Product	serving size/g	Oxalate(mg/g)	oxalate (mg/svg)	HCN (mg/g)	HCN (mg/svg)	Fe (mg/kg)	Zn (mg/kg)
BFBN-1	Rice	15	0.14	2.16	0.29	4.31	47.58	2.96
BFBN-2	Oat& MF	15	0.17	2.53	0.20	10.06	53.44	17.28
BFBN-3	MA	15	0.12	1.86	0.24	3.59	53.24	0.82
BFB-1	Fruits	32	0.08	2.56	0.31	10.06	42.82	1.72
BFB-2	MH	48	0.27	12.88	0.17	7.94	31.26	3.86
BFB-3	CN	48	0.09	4.10	0.27	13.17	70.08	23.88
BFB-4	MC	32	0.24	7.60	0.23	7.22	38.80	17.30
BFC-1	Maize	50	0.10	5.10	0.21	10.64	73.52	15.32
BFC-2	Wheat	50	0.23	11.62	0.26	12.96	40.44	1.96
BFC-3	FW	50	0.13	6.34	0.21	10.42	24.12	4.60
BFF-1	Lactea	30	0.17	5.17	0.07	1.96	27.60	5.04
BFN-1	Fiber	50	0.11	5.37	0.34	17.06	54.68	1.64
BFN-2	Maize	20	0.09	1.83	0.12	2.36	34.12	13.88
BFN-3	Rice	20	0.08	1.67	0.31	6.26	211.96	33.88
BFN-4	Oat	20	0.11	2.29	0.17	3.41	220.76	23.12
BFP-1	MF	30	0.09	2.67	0.36	10.66	135.12	20.88

CN-capital nutrition; MH-milk & honey; MF-mixed fruits; FW-fruits & wheat; MC-multi cereal; MA-muesli with apple