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INVESTIGATION OF THE MINERAL CONTENTS OF SOME VARIETIES OF POWDER MILK BY PIXE

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Milk and milk products constitute an important ingredient of human nutrition all over the world. Macro mineral contents like sodium, potassium, calcium, phosphorus and micro mineral contents like iron, copper, zinc, manganese of some varieties of powder milk available in the local market have been investigated by Proton Induced X-Ray Emission (PIXE). These elements are essential for the optimal functioning of various chemical processes taking place in the human body. Any toxic element present in milk can also be detected simultaneously. PIXE is a powerful and universal elemental analysis technique with high detection sensitivity for elements with Z> 11 in the periodic table. The technique is non-destructive and may be applied to samples as small as a cell to a large painting.

Keywords : Milk product, Micro mineral contents, Proton induced x-ray emission (PIXE),

1. Introduction

Milk and its products constitute a very important and essential part of human nutrition especially in infants who are entirely dependent upon this complete diet, at least for the first few months of their lives. Milk may be defined as an emulsion of fat globules in an aqueous suspension comprising casein, calcium and phosphorus alongwith whey proteins, lactose and mineral salts [1]. It is the natural secretion of the mammary gland and is unique in composition for each mammalian species.

After the early phase of human life cow's milk starts to play a fundamental role in the growth and development of the human body. Fresh cow's milk can be converted into various products by removing water which constitutes about 88 percent by weight.

The mineral elements present in milk constitute a set of important nutrients required by the human body for optimal performance. The minerals present in milk may be divided in to two broad categories of macro and micro minerals. Sodium, potassium, magnesium, phosphorus and calcium constitute the macro minerals whereas copper, zinc, iron and manganese constitute the micro minerals [2, 3].

Several brands of powder milk are produced and marketed in Pakistan. Some of the commonly available brands in the market include Nestle, Nido, Nestle Everyday, Haleeb's Skimz and Millac. The manufacturers of instant milk claim to have fortified their products with certain minerals, however, the details of the mineral contents are not indicated on the product.

In the present study the mineral content of three of these products have been investigated by proton induced x-ray emission (PIXE) to ascertain the composition of these brands of powder milk (labeled A, B, C) purchased from the local market.

2. Experimental

Two grams of milk from each sachet of the powder milk purchased from the market was dissolved in one ml of water and one drop applied to a 35 micrometer thick myler substrate. The milk was dried in a desiccator under a lamp. The samples were mounted on a small carbon pyramid before irradiation by the proton beam from 6S DH2 pelletron accelerator at the High Tension Laboratory of CASP, Government College University, Lahore. The carbon pyramid can take four samples at a time for irradiation in turn. The samples were irradiated by 3 MeV protons. The beam current was 8 nA and the beam diameter

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was 2.5 mm. Each sample was irradiated only once. The x-rays emitted by the sample were monitored by a liquid nitrogen cooled 30 mm diameter Si(Li) detector placed at right angle to the proton beam at a distance of about 8 cm. The signal produced by the Si(Li) detector was processed electronically before being analysed and displayed by the multichannel analyser as counts (amplitude) versus channel number (X-ray energy) spectrum. The system was energy calibrated using Au L X-rays. Each sample was exposed for 600 seconds. Schematic of the experimental setup is shown in Figure 1.

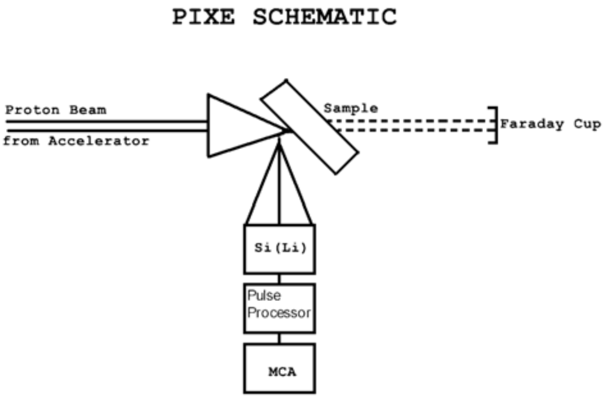

Figure 1. Schematic arrangement of PIXE experiment.

PIXE spectrum of one of the samples as displayed by the MCA is shown in figure 2. Elemental analysis was carried out using GUPIX software supplied by NEC USA.

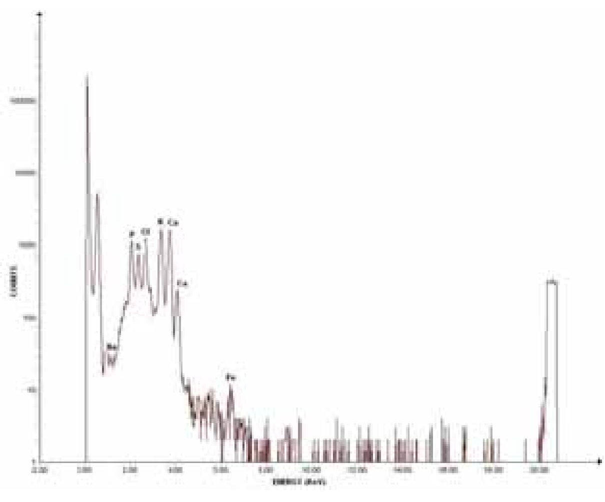

Figure 2. PIXE spectrum of milk powder.

3. Results and Discussion

The samples were placed in a vacuum chamber and the total `time for the run was less than 45 minutes. Actual irradiation time was 30 minutes, the remaining time accounts for manual change and adjustment of the samples. The result of the analysis for the major as well as minor mineral contents of the milk samples is produced in Table 1 alongwith the literature values for goat milk powder [4], fresh milk [5] as well as for IAEA Reference Material (RM) IAEA-153 (Milk Powder). In order to carry out quality assurance and show the reliability of our results we analyzed IAEA RM IAEA-S-7 (Soil-7). This was due to the unavailability of matrix specific RMs such as IAEA-153. Although IAEA-S7 is not a matrix specific RM it verified our analytical procedure as the results obtained for all of the elements studied except Cl, which is not certified in IAEA-S-7, were found to lie within ±3SD. This is an initial study and is being used to test and calibrate our PIXE facility. However, in future the matrix specific RMs would be used and analyzed alongwith the samples to obtain accurate and reliable results.

A perusal of Table 1 shows that the concentration levels of the elements studied in fresh milk are an order of magnitude lower than those cited for IAEA-153 and goat milk powder as well as the results obtained in this work. This is because fresh milk generally contains ~90% water [4]. Furthermore the amounts of most elements obtained for samples A, B and C are comparable in magnitude to those cited for IAEA-153 and goat milk powder. The exceptions are Na, Mg and Fe. Na and Mg were determined in only one sample whereas the Fe content of the three powder milk samples is higher than the reported values. Elements with lower atomic number are better analyzed using Proton Induced Gamma Emission (PIGE). This is especially the case for elements such as Na. No data was cited for S, Cl, Mn, Co and Cu in IAEA-153 and goat milk powder but their amounts in fresh milk are at least an order of magnitude lower than the data obtained for the 3 samples analyzed. However the presence of chlorine and cobalt in the samples may probably be due to the substrate material.

Sodium is an important cation present in the extra cellular fluid and plays a vital role in the nerve and muscle function, acid-base balance and regulation of plasma volume [6]. Body requirement

Table 1. Concentration and SD (in mg/kg) of major and minor element in three brands of milk powder.

Element	Sample A	Sample B	Sample C	IAEA-153 (milk powder)	Goat Milk Powder[4]	Fresh Milk[5] mg/lit
Na	-	-	135±110	4180±293	-	250-640
Mg	99±73	-	-	1060±74	-	70-140
P	3640±60	3250±80	6310±110	10100±1010	7471	800-1000
S	226±7	393±12	421±13	-	-	-
Cl	980±20	1000±16	1100±20	-	-	800-1200
K	26120±230	30490±260	25410±290	17620±1233	-	1100-1500
Ca	4730±30	3310±33	3241±47	12870±386	7715	1100-1300
Mn	2.3±0.2	4.1±0.6	3.9±0.3	-	-	0.01-0.05
Fe	50.5±12.3	72.8±3.5	74.1±16.3	2.53±0.91	3.33	0.10-0.70
Co	22.5±12.4	11.4±7.3	-	-	-	*0.5-1.3
Cu	19.6±1.8	28.5±2.0	-	-	-	0.10-0.35
Zn	41.7±15.4	19.0±9.1	-	39.6±1.6	30.21	2.50-7.00

* Conc. in μg/lit

of sodium for an average person is 1 gram per day. Intake of sodium in excess may cause an early onset of hypertension and worsen the already existing problem. Combined with sodium, potassium also plays an important role to maintain a balance between the intracellular and extra cellular fluids in the body. Electrical pulses in the nerves are produced by momentary exchange of sodium and potassium ions [7]. Potassium also plays a role to regulate the blood pressure, osmotic pressure and acid-base balance [8]. Table 1 shows that milk is a rich source of potassium.

Calcium is an essential element for the development of bones and teeth which contain 98 percent of calcium present in the body [9]. As can be seen from Table 1 milk is a very rich source of calcium. Phosphorus is the second most abundant element in the human body. Most of the phosphorus combines with calcium to constitute bones and teeth. The remaining about 20 percent is used for cell growth and muscle contraction in the heart [10]. Present study shows milk to be a primary source of phosphorus in human body. Together with phosphorus and calcium most of magnesium in the human body is found in the bones. Iron plays an important role to control many processes in the human body [11]. Diet deficient in iron can cause anemia which affects about 2000 million persons worldwide. Table 1 shows small amount of iron present in the powder milk samples under study. Zn is an important trace element present in our body. It is required for weight gain and height improvement. Milk is a very good source of Zn as evident from Table 1. Copper is third most abundant trace element in our body after iron and Zn [12]. A daily intake of 1.5-3 mg of copper is recommended for adults (FNB 89). Fresh cow milk contains 0.011 mg of copper per 100 grams [13, 14]. Present study indicates that powder milk is a rich source of copper and contributes substantially of our daily requirement. Manganese in our body is required for the enzyme activity. This element is present in sufficient quantity in the powder milk to meet our daily requirement.

4. Conclusions

The present study using PIXE has shown powder milk to be an important source of minerals requirement for the human body. The presence of chlorine and cobalt in the sample is probably due to the substrate material.

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