Eurasian Journal of Analytical Chemistry
ISSN: 1306-3057 OPEN ACCESS 2021 16 (2): 01-09

Potential Toxic Elements (PTEs) and the Health Risk Impact of Some Dairy Products Marketed in Nigeria

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Received: 16 January 2021 ▪ Revised: 26 February 2021 ▪ Accepted: 15 March 2021

Abstract: Dairy products (Yoghurts, Butter and Cheese) available in Nigerian markets were analyzed for Zn, Cu, Sn, Ni, Fe, Cd, Cr, Mn and Pb. Flame Atomic Absorption Spectrophotometer (FAAS) was used to determine the metals after digestion and their potential health risks assessed. The result showed the following mean detectable concentration range (mg/kg) of the potential toxic elements (PTEs) in yoghurt: Cd = 0.0197 - 0.0630, Cu = 0.0647 - 0.0323, Ni = 0.3077 - 0.2051, Mn = 0.0540 - 0.0432, Zn = 0.9351 - 0.1125, Fe = 0.7336 - 0.4076. Butter: Cd = 0.12 - 0.0050, Ni = 0.7179 - 0.5128, Mn = 0.0540 - 0.0324, Zn = 0.9374 - 0.3668 and Cheese: Cd = 0.0297 - 0.0225, Ni = 0.8547 - 0.2051, Mn = 0.0972 - 0.0540, Zn = 1.2294 - 0.2136, Fe = 0.8559 - 0.4075 and Sn = 0.0057 - 0.0047. The health risk assessment showed health risk index of Cd and Ni to be above one indicating probable health risk associated with the consumption of most of the dairy products. Though the health risk associated with the intake of Cu, Mn, Sn, Fe and Zn through the consumption of these dairy products did not show probable risk, their concentrations should be monitored. Their accumulation in the human body as a result of continual consumption might pose health challenge to the consumers. Therefore, routine evaluation of these PTEs should be sustained to ensure their concentration does not exceed the safe limits.

Keywords: Potential Toxic Elements, Yoghurt, Dairy Product, Health Risk, Milk.

INTRODUCTION

Milk derived products are essential members of the human beings' diet. The main component of dairy products has been described as a complete food because it contains vital nutrients, including proteins, essential fatty acids, lactose, vitamins, and minerals in balanced proportions [1]. However, milk and dairy products can also contain chemical hazards and contaminants, which constitute a risk factor for dairy products consumer's health [2].

Cream is a fat-rich component and has been known from time immemorial as the fatty layer that rises to the top portion of the milk when left undisturbed. Cream excluding sterilized cream is cow or buffalo milk or a combination of both, which contains not less than 25 percent milk fat [1]. The cream is rich in energy-giving fat and fat-soluble vitamins A, D, E, and K, the contents of which depend on the fat level in cream.

Butter is a fat-rich dairy product, generally made from cream by churning. It contains 80% fat, which is partially crystallized. Butter making is one of the oldest forms of preserving the fat component of milk. Its manufacture dates back to some of the earliest historical records. Reference has been made to the use of butter in sacrificial worship, medicinal and cosmetic purposes, and human food long before the Christian era [3]. Butter can be produced from the milk of cow, buffalo, camel, goat, ewe, and mares. Cheese is the

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curd or substance formed by the coagulation of certain mammals' milk by rennet or similar enzymes in the lactic acid presence [3]. This lactic acid is produced by added or adventitious microorganisms from which part of the moisture has been removed by cutting, warming, and pressing, shaped in a mold, and then ripened (also unripen) holding for some time at suitable temperatures and humidity [3].

Yoghurt is a dairy product prepared by bacterial fermentation of milk. The equal amount of two pure bacteria cultures, namely: *Streptococcus thermophiles* and *Lactobacillus bulgarisis* is added to whole or defatted homogenized milk to make yoghurt [1]. The starter cultures determine the texture and flavor of the final yoghurt [4]. Starter cultures preserve the food by synthesizing lactic acid bacteria and antimicrobial substances [5]. Fruits in yoghurt provide an aroma, which is very much enjoyed by everybody [6]. Yoghurt contain fat (0.0 to 3.5%), solids (8.25-14%), sugar (0-10%) and stabilizer (0.0 to 2%) [1].

Potential toxic elements (PTEs) have been identified as the primary cause of various health problems ranging from cancer, dementia, and low intelligence quotient to death [7]. Dairy animals can ingest these PTEs, and because of their non-degradable nature, they are transferred to the mammary glands of these animals. Numerous dairy products abound in markets in Nigeria. They are consumed daily with the focus only on their health benefits without recourse to their PTEs content, and this negligence can lead to detrimental health effects if left unchecked.

MATERIALS AND METHODS

Sampling

Yoghurt, Cheese and butter were purchased from the local markets in January, 2019, at Nsukka and Enugu, in Enugu State, Nigeria. Three brands of each of the dairy products were sampled (Yoghurt - RY, HY, DY, Butter – BB, MB, MMDB and Cheese – PLTC, HCC, LWCC). Three samples of each brand were purchased in their original packages and then taken to the laboratory in an ice box. Each brand was randomly selected from different stalls at different locations within the city. A homogenized composite sample was then collected by careful mixing of three samples of each brand.

Table 1: Diary Products, country of origin, manufacturing date and expiry date

Sample Codes	Country of Origin	Date of Manufacture	Expiry Date
RY	Nigeria	3rd October, 2018	24th October, 2019
HY	Nigeria	May, 2018	April, 2019
DY	Nigeria	July, 2018	June, 2019
BB	Nigeria	8th October, 2018	8th July, 2019
MB	Malaysia	20th January, 2018	20th July, 2019
MMDB	Nigeria	10th June, 2018	1st May, 2019
PLTC	France	21st December, 2018	21st December, 2019
HCC	Austria	24th November, 2018	23rd November, 2019
LWCC	South Africa	20th November, 2018	19th November, 2019

Trace Metal Analysis

About 2g sample was digested with a mixture of HNO_3 and $HClO_4$ (4:1 *v/v*) and heated at 70°C for 2hours to obtain a transparent solution. The sample was filtered and made up to a suitable concentration for analysis using FAAS (AA-7000, Germany) [8] after the acid digestion.

Quality Control Measures

All reagents used were of analytical grade from Merck Chemical Company, USA. Glasswares were of Pyrex material, washed with detergent and cleansed by soaking in 10% *v/v*HNO_3. Then, they were rinsed several times with de-ionized water before usage. The samples were spiked with various standard solutions of the metals. Triplicate analysis of both the spiked and un-spiked samples were carried out throughout the experiment. The percentage recovery was calculated using equation 1[9]:

$$\%Recovery = \left[\frac{a-b}{c}\right] \times 100 \qquad (1)$$

Where a = concentration of spiked sample

b = concentration of unspiked sample

c = concentration of the PTE added

The Limit of Detection (LOD) and Limit of Quantification (LOQ)

LOD and LOQ are used to describe the minutest amount of the analyte that can be detected and measured respectively with reliability by an analytical procedure. LOD describes the least amount of the analyte that can be observed but not quantified within the method of analysis. LOQ describes the amount of the analyte that is determinable under the condition of analysis [10].

The LOD was determined as three times the standard deviation (S.D) of ten runs of the blank measurements as previously described [11].

$$LOD = 3 \times S.D_{blank} \quad (2)$$

LOQ was measured as the concentration corresponding to sample blank value plus ten standard deviations as proposed by Shrivasatava & Gupta [10].

$$LOQ = \text{Mean of Blank} + (10 \times S.D_{blank}) \quad (3)$$

Health Risk Index (HRI)

Using the non-carcinogenic health risk assessment model, the contamination level of the selected PTEs in the dairy products was assessed using the health risk index equation 4[12]:

$$HRI = \frac{EDI}{ADI} \quad (4)$$

Where HRI is the Health Risk Index, EDI is the Estimated daily Intake and ADI is the Acceptable Daily Intake.

The EDI was determined by multiplying the PTEs concentration (C) in the sample (mg/kg) by the food consumption rate (F) (kg/day) and dividing by the mean body weight. The food consumption data used was as reported by Akinyosoye [13]. Calculations were performed for adults and children. Adults were considered to have an average body weight of 60 kg, while children (2 – 5 years) were considered to have an average body weight of 16.7 kg [14]. This age range for children was selected because they have increased risk of exposure resulting from their lower body weight [14].

$$EDI = \frac{F \times C}{BW} \quad (5)$$

Where F = Food Consumption Rate and C = Concentration of the PTEs in the sample and BW = mean body weight. F was got by dividing the food consumption data for the year by the estimated population and the number of days in one year [15].HRI less than one indicate that the group exposed is not likely to feel apparent ill effects. The severity of health risk caused by PTEs in food enhances increasing HRI value [16].

RESULTS AND DISCUSSION

Recovery Analysis

Table 2 shows the results of the recovery analyses of the PTEs analyzed as a measure of method validation.

Table 2: Percentage Recovery of the PTEs and LOD and LOQ

Heavy Metals	Amount of Spike (ppm)	Spiked Sample (ppm)	Unspiked Sample (ppm)	Recovery Value (ppm)	Percentage Recovery	LOD (ppm)	LOQ (ppm)
Chromium	2.00	2.6667	0.6670	1.9997	99.99	0.00001	0.00010
Cadmium	2.00	2.0300	0.0225	2.0075	100.38	0.00001	0.00020
Lead	2.00	1.7500	0.0000	1.7500	87.50	0.00001	0.00010
Copper	2.00	1.9723	0.0000	1.9723	98.62	0.00001	0.00010
Nickel	2.00	3.0000	0.8947	2.1053	105.27	0.00001	0.00010
Manganese	2.00	1.9444	0.0000	1.9444	97.22	0.00001	0.00010
Zinc	2.00	2.7186	0.7907	1.9279	96.40	0.00001	0.00010
Iron	2.00	2.4454	0.4483	1.9971	99.86	0.00001	0.00015
Tin	2.00	1.9210	0.0000	1.9210	96.05	0.00001	0.00020

PTEs in the Dairy Products

Nine trace metals (Cd, Pb, Cu, Ni, Mn, Zn, Fe, Cr) were assessed in the three different cheese brands (Table 3). The mean concentration of Cr in PLTC was 0.6670mg/kg, though it was undetectable in HCC and LWCC. The appearance of Cd in milk derived products could be from natural or anthropogenic sources (depositions from the atmosphere and fertilizers). Cd is one of the most serious contaminants in recent times. Cd concentrations in cheese samples were in the range of 0.0225 to 0.0297mg/kg with the highest concentration of 0.0297mg/kg observed in HCC. Pb and Cu were not detected in all the cheese samples. Pb contamination of dairy products has extensively been studied. Ibrahim [17], Al-Ashmawy *et al.*[18] and Deeb (2010) [19]observed higher Pb concentrations (0.13-0.98, 0.03–0.2 and 0.09–1.83mg/kg respectively) in cheese. These values were higher than the values observed in this study. The appearance of Pb in milk derived products could be from environmental sources (deposition from atmosphere, industrial waste discharge, discharge from vehicle exhausts, domestic effluent discharge). Water and foodstuff may contribute to the body load of PTEs.

Maximum Ni concentration was observed in PLTC (0.8547mg/kg) and the minimum concentration was obtained in LWCC (0.2051mg/kg). Whereas Mn was not detected in PLTC, its concentrations of 0.0540mg/kg and 0.0972mg/kg were recorded in HCC and LWCC respectively. Zn was found to be of the highest amount in HCC with a mean concentration of 1.2294mg/kg followed by PLTC with 0.7907mg/kg, while LWCC showed the least mean concentration of 0.2136mg/kg. These concentrations were lower than 2.73–18.316 ppm reported for Zn by Meshref *et al* [20] in cheese sample.

Zn is essential for the structure and the functionality of over 300 enzymes needed for nucleic acid and protein synthesis, cellular modification and reduplication, insulin secretion, sexual development and it could also be implicated in the functional accomplishments of the immune system and some physiological activities [21]. LWCC showed the highest mean Fe concentration of 0.8559mg/kg. Iron acts as catalyst in many metabolic processes. As one of the contents of myoglobin, hemoglobin, cytochromes and some proteins, it performs an important function in the storage, transport and usage of oxygen [20]. It also acts as coenzyme for many enzymes and its in adequacy could lead to anemia [20]. Sn was not detected in PLTC but was found to be 0.0047mg/kg and 0.0057mg/kg in HCC and LWCC respectively.

Of the three Yoghurt brands analysed, Cr and Pb were not detected in the entire yoghurt brand (Table 3). Cd was found to be prevalent in RY with a mean concentration of 0.0630mg/kg and least in DY with a mean concentration of 0.0197mg/kg. Whereas Cu was not detected in HY, it was present in DY and RY at mean concentrations of 0.0323mg/kg and 0.0647mg/kg respectively. Cu, an important trace metal is essential for proper growth, soundness of the cardiovascular system, resilience of the lungs, neuronendocrine activity, and iron metabolism [22]. Abdel-Rahman *et al.,*[23] reported 0.23mg/kg and below detection limit (<bl) for Cu and Cd respectively in Mango flavored yoghurt sold in Egyptian Market. Therefore, milk derived products are seen as unimportant source for Cu; however, Cu inadequacy is not common except in situations of acute malnutrition [20]. Ni was detected in all the yoghurt brands at mean concentrations of 0.3077mg/kg, 0.2051mg/kg and 0.2393mg/kg corresponding to DY, HY and RY respectively. Mn was detected in both DY and HY but was not detected in RY. For Ni and Mn, Abdel-Rahman *et al.* [23] reported 0.51 and 0.10mg/kg respectively which were above the present result. Zn was detected in all the brands and showed the highest mean concentration in RY. Tin was only detected in RY while Iron was found to be present in all three brands with the highest mean concentration of 0.7336mg/kg observed in RY.

The mean concentration of the PTEs in the butter samples analysed is as presented in Table 3. Of the PTEs assayed, Cr and Pb were not detected. Sn was present in only BB with a mean concentration of 0.0023mg/kg. Cd was present in the three brands with the highest mean concentration of 0.1200mg/kg observed in MMDB. BB and MB showed the same mean concentration of 0.0431mg/kg for Cu. Cu along with Fe is a pointer of the final quality of item, as these metals perform biological and nutritional roles. Notwithstanding, they may present a problem in milk derived product technology as a result of their catalytic effect on oxidation of lipids with aftereffects of quality blotch. Concentration of Fe and Cu more than 1.5 mg/kg in milk will not give room for a prolonged storage of butter and cream [24]. Fe was observed in all the brands with MMDB showing the highest mean concentration of 0.9374mg/kg and BB showing the least mean concentration of 0.3668mg/kg. Zn, Mn and Ni were detected in all the samples. Whereas Zn showed the highest mean concentration of 0.2713mg/kg in BB, Mn was highest in MMDB with a mean concentration of 0.0540mg/kg while MB and BB showed the same mean concentration of 0.7179mg/kg for Ni.

In Cheese samples, Cr maximum residual limits (MRL) were below the standard according to Italian standard as reported by Licata *et al.* [2], (2.03 mg/kg), but Cd was above the recommended residual level according to the Egyptian standard in all the three samples of cheese examined. Harlia *et al.* [25], reported high levels of Pb and Cd in 30 samples of milk and milk derived products collected from farmers in Pemulihan subdistrict, Sumedang Regency. Ni MRL value was above that recommended by the National standard according to Saleh *et al.* [26], (0.2 mg/kg). In the case of Yoghurt samples, Cd was below the MRL value according to the Egyptian standard of 0.2mg/kg. Similar result was observed for Fe, Cu and Zn according to Holland *et al.* [27]. Cd in Butter sample (MMDB) was above the MRL value according to the Egyptian standard, but every other metal under consideration were either not detected or having MRL value below the recommended value.

Table 3: Mean Concentration ± SD of PTE in Cheese, Yoghurt and Butter Samples and their respective MRL (mg/kg)

Sample	Sample Code	Cr	Cd	Pb	Cu	Ni	Mn	Zn	Fe	Sn
Cheese	PLTC	0.6670±0.000	0.0225±0.0007	ND	ND	0.8547±0.3602	ND	0.7907±0.1381	0.4483±0.0706	ND
	HCC	ND	0.0297±0.0055	ND	ND	0.8205±0.2714	0.0540±0.0187	1.2294±0.2901	0.4075±0.0706	0.0047±0.0003
	LWCC	ND	0.0257±0.0021	ND	ND	0.2051±0.1026	0.0972±0.0324	0.2136±0.0577	0.8559±0.2118	0.0057±0.0021
Yoghurt	DY	ND	0.0197±0.0025	ND	0.0323±0.0324	0.3077±0.1026	0.0432±0.0187	0.1125±0.0458	0.4891±0.1223	ND
	HY	ND	0.0367±0.0035	ND	ND	0.2051±0.1026	0.0540±0.0187	0.1530±0.0100	0.4076±0.0706	ND
	RY	ND	0.0630±0.0026	ND	0.0647±0.0324	0.2393±0.1184	ND	0.9351±0.1190	0.7336±0.1223	0.0030±0.0000
Butter	BB	ND	0.0070±0.0044	ND	0.0431±0.0187	0.7179±0.2713	0.0324±0.0000	0.2713±0.0507	0.3668±0.0.000	0.0023±0.0015
	MB	ND	0.0050±0.0010	ND	0.0431±0.0187	0.7179±0.1026	0.0432±0.0187	0.1905±0.0770	0.5299±0.1412	ND
	MMDB	ND	0.1200±0.0053	ND	ND	0.5128±0.1026	0.0540±0.0187	0.1443±0.0608	0.9374±0.2545	ND

ND - Not Detected, SD - Standard Deviation

Health Risk Index of the PTEs

Table 4 shows the health risk index of the PTEs in the samples. Of all the PTEs analyzed in the samples, Cr was the only PTE with hazard risk index (HRI) value greater than one in both adult and children with the highest HRI in children (35.57). Ni and Cd showed risk index for children in butter, yoghurt and cheese as well. The risk factor for dietary exposure to these heavy metals for consumers of DY increases in the order Cd>Ni>Fe>Zn>Mn>Cu>Sn=Pb=Cr considering the HRI of the PTEs.

The results recorded in Table 3 showed that the average concentration of Cd, Cu, Mn, Ni, Zn and Fe in the examined DY samples were 0.0197, 0.0323, 0.3077, 0.0432, 0.1125 and 0.4890 mg/kg respectively. These concentrations gave an estimated daily intake of about 0.0072, 0.0118, 0.1128, 0.0158, 0.0413 and 0.1793 mg/person/adult, respectively and these quantities represents10.29, 0.39, 11.28, 0.32, 0.28 and 0.996% of the acceptable daily intake (Codex, [28], WHO, [29], IMNAS, [30] and IMNAS and FNB, [31] and Perveen *et al*. [32]). Also, the estimated daily intake (EDI) for children respectively gave 263, 0.86, 68, 96, 3.0 and 4.3 % of the acceptable daily intake recommended for children. For BB butter, the average concentrations of 0.007, 0.0431,0.7179, 0.0324, 0.2713, 0.3668 and 0.0023 mg/kg for Cd, Pb, Cu, Mn, Ni, Zn, and Fe respectively gave an estimated daily intake of 0.0083, 0.0158, 0.2632, 0.0119, 0.1345 and 0.0008 mg/person/adult. This represents 11.86, 0.53, 26.32, 0.24, 0.66, 0.75 and 0.04% of the acceptable daily intake recommended. It also represents 93, 1.15, 159.53, 7.20, 7.23and 3.26 % for Cd, Pb, Cu, Mn, Ni and Zn, respectively for children's daily intake. Garba *et al*. [33], reported 4.904±0.101, 1.252±0.021, 1.191±0.031, 0.333±0.017, 0.102±0.008 and 0.025±0.012 μg/g for Fe, Pb, Mn, Zn, Cu and Co respectively in cow milk from Maiduguri metropolis, Borno State Nigeria. Ihedioha and Okoye [34], assessed the concentrations of Cd and Pb in the muscle, liver, kidney, intestine, and tripe of cows in Nigeria, and concluded that Cd was accumulated mainly in the kidney, while Pb accumulated mostly in the liver, and both toxic metals were above the maximum, international permissible levels in most samples. Pollutants may arise from raw materials used in production, poor quality production processes, adulteration and preparation [35]. This supports the fact that dairy products PTEs contents may be from the raw materials (milk and water) used in their production. In cheese sample, PLTC which recorded PTE concentrations of 0.6670, 0.0225, 0.8547, 0.7907 and 0.4483 mg/kg for Cr, Cd, Ni, Zn and Fe gave estimated daily intake of 0.2445, 0.0083, 0.3134, 0.2899 and 0.1644 mg/person/adult. This estimated daily intake represents698.85, 11.85, 31.34, 1.93 and 0.11 % respectively for adult and 2.22, 300, 113.96, 2.11 and 3.98 % for children respectively.

The result of the health risk assessment of PTEs in Table 4 for yoghurt showed a significant contamination health risk for children in DY, HY and RY with HRI values of 2.6267, 4.8933 and 8.4000 respectively. It has been reported that children are more susceptible to some heavy metal exposures due to their increased intestinal absorption and their lower threshold for adverse effects compared to adults [36, 37].The cheese samples, PLTC, HCC and LWCC showed Cd contamination health risk in children with HRI of 3.00, 3.96 and 3.4267 respectively. While other heavy metals assayed fell within the acceptable concentration range. It was only MMDB butter sample that had risk index of 16.00 (greater than 1).

Table 4: Average Daily Intake (mg/kgbw/day), Estimated Daily Intake (mg/kg.bw/day) and Hazard Risk Index for Adult and Children

Sample	Parameter	Cr	Cd	Pb	Cu	Ni	Mn	Zn	Fe	Sn
DY	**ADI (Adult)**	[f]0.035	[m]0.07	[k]0.25	[n]3.0	[f]1.0	[q]5.0	[n]15.0	[n]18.0	[f]2
	ADI (Children)	[f]0.025	[c] 0.01	[a] 0.036	[c]5.0	[f] 0.6	[e]0.6	[d]5.0	[d]15.0	-
	EDIA	-	0.0072	-	0.0118	0.1128	0.0158	0.0413	0.1793	-
	HRIA	-	0.1032	-	0.0039	0.1128	0.0032	0.0028	0.0099	-
	EDIC	-	0.0263	-	0.0431	0.4103	0.0576	0.1500	0.6521	-
	HRIC	-	2.6267	-	0.0086	0.6838	0.0960	0.0300	0.0435	-
HY	**EDIA**	-	0.0135	-	-	0.0752	0.0198	0.0561	0.1495	-
	HRIA	-	0.1922	-	-	0.0752	0.0040	0.0038	0.0083	-
	EDIC	-	0.0489	-	-	0.2735	0.0720	0.2040	0.5435	-
	HRIC	-	4.8933	-	-	0.4578	0.1200	0.0408	0.0362	-
RY	**EDIA**	-	0.0083	-	0.0237	0.0877	-	0.3429	0.2690	0.0011
	HRIA	-	0.1179	-	0.0079	0.0877	-	0.0229	0.0149	0.0006
	EDIC	-	0.0630	-	0.0647	0.2393	-	0.9351	0.7336	-
	HRIC	-	8.4000	-	0.0173	0.5318	-	0.2494	0.0652	-
BB	**EDIA**	-	0.0083	-	0.0158	0.2632	0.0119	0.0995	0.1345	0.0008
	HRIA	-	0.1179	-	0.0053	0.2632	0.0024	0.0066	0.0075	0.0004
	EDIC	-	0.0093	-	0.0575	0.9572	0.0432	0.3617	0.4891	-
	HRIC	-	0.9333	-	0.0115	1.5953	0.0720	0.0723	0.0326	-
MB	**EDIA**	-	0.0083	-	0.0158	0.2632	0.0158	0.0699	0.1943	-
	HRIA	-	0.1179	-	0.0053	0.2632	0.0032	0.0047	0.0108	-
	EDIC	-	0.0067	-	0.0575	0.9572	0.0576	0.2540	0.7065	-
	HRIC	-	0.6667	-	0.0115	1.5953	0.0960	0.0508	0.0471	-
MMDB	**EDIA**	-	0.0083	-	-	0.1880	0.0198	0.0529	0.3437	-
	HRIA	-	0.1179	-	-	0.1880	0.0040	0.0035	0.0191	-
	EDIC	-	0.1600	-	-	0.6837	0.0720	0.1924	1.2499	-
	HRIC	-	16.000	-	-	1.1396	0.1200	0.0385	0.0833	-
PLTC	**EDIA**	0.2446	0.0083	-	-	0.3134	-	0.2899	0.1644	-
	HRIA	6.9876	0.1179	-	-	0.3134	-	0.0193	0.0091	-

	EDIC	0.8893	0.0300	-	-	1.1396	-	1.0542	0.5977	-
	HRIC	35.5733	3.0000	-	-	1.8993	-	0.2109	0.0398	-
HCC	**EDIA**	-	0.0109	-	-	0.3009	0.0198	0.4508	0.1494	0.0017
	HRIA	-	0.1556	-	-	0.3009	0.0040	0.0301	0.0083	0.0009
	EDIC	-	0.0396	-	-	1.0940	0.0720	1.6392	0.5433	-
	HRIC	-	3.9600	-	-	1.8233	0.1200	0.3278	0.0362	-
LWCC	**EDIA**	-	0.0094	-	-	0.0752	0.0356	0.0783	0.3138	0.0021
	HRIA	-	0.1346	-	-	0.0752	0.0071	0.0052	0.0174	0.0010
	EDIC	-	0.0343	-	-	0.2735	0.1296	0.2848	1.1412	-
	HRIC	-	3.4267	-	-	0.4558	0.2160	0.0570	0.0761	-

ADI – Average Daily Intake, EDIA – Estimated Daily Intake for Adult, EDIC – Estimated Daily Intake for Children, HRIA – Health Risk Index for Adults, HRIC – Health Risk Index for Children, - not calculated. [a]WHO 2000[38], [b]WHO 2001 [39], [c]WHO 1982[40], [d]National Academy of Science, Washington, DC, U.S.A 2004 [41]. [e]EFSA, 2009[12], [n]IMNAS, 2000 [30], [f]IMNAS and FNB, 2001 [31], [k]Codex Stand 193-1995 [28], [m]WHO, 1996 [29], [q]Perveen et al 2005 [32].

The risk factor with respect to the HRI of the PTEs for the dietary exposure of HY consumers increases in the order Cd>Fe>Ni>Zn>M>Sn=Pb=Cu=Cr. Of the PTEs examined in RY (Table 4), Cd showed a high health risk index, while the rest fell within the low-risk range. The observed trend in the risk factor for dietary exposure to these PTEs for consumers of RY increases in the order Cd>Zn>Fe>Ni>Cu>Sn>Mn=Pb=Cr. Table 4showed the result of health risk indices associated with consumption of BB. Of the nine PTEs assessed, Ni showed a significant health risk for children while the rest fall within the low-risk range. The observed trend in the risk factor for dietary exposure to these PTEs for consumers of BB increases in the order Ni>Cd>Zn>Fe>Cu>Mn>Sn>Pb=Cr. Ni also showed a high contamination health risk for children only. The other PTEs determined showed health risk indices within the low-risk index and the trend for the risk factor as a result of the dietary exposure increases in the order Ni>Cd>Fe>Zn>Mn>Cu>Sn=Pb=Cr. For MMDB, PLTC, HCC and LWCC, The risk factor for dietary exposure to these PTEs for their consumers increases in the order Cd>Ni>Fe>Zn>Mn>Sn=Cu=Pb=Cr, Cr>Cd>Ni>Zn>Fe>Sn=Pb=Cu=Mn, Cd>Ni>Zn>Fe>Mn>Sn>Pb=Cu=Cr and Cd>Fe>Ni>Mn>Zn>Sn>Pb=Cu=Cr respectively.

CONCLUSION

The concentration of potential toxic elements in dairy products was evaluated using FAAS after sample digestion. It could be observed generally that Ni and Cd pose a significant health risk to the consumers of these dairy products, while Pb, Cr, Sn, Zn, Mn, Cu and Fe were below the health risk threshold in most of the products examined. The high levels of Cd in the dairy products could be from the use of milk which already has higher concentration of Cd and Ni and/or water used for production of these dairy products which may not have been properly treated. It is noteworthy that the risk associated with PTEs contamination of foods and food products lie in accumulation effect. This suggests that even those PTEs found to be below the HRI threshold cannot be regarded as being harmless because their build-up over time could cause serious health effects to the consumers. Therefore, appropriate actions should be taken to monitor the PTE levels of these foods and food products with the aim of reducing to as less as possible, the concentrations of these PTEs in foods and dairy products.

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