Heavy Metals Content and Polycyclic Aromatic Hydrocarbons Present in Selected Infant Milk Formulae and Cereals Sold in Port Harcourt, Nigeria

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Abstract

Excessive exposure to contaminants like heavy metals and polycyclic aromatic hydrocarbon in infant formulae and cereal consumption can have harmful effects on the human health. This work investigated five infant-milk formulae (AA, BB, CC, DD and EE) and five cereals (NN, CL, NM, NC and FF) sold in Port Harcourt, analysing them for heavy metals and PAHs. Heavy metals in the samples were analysed using absorption spectroscopy, and Gas Chromatography-Mass Spectrometry was used for the PAHs. The concentration of iron, arsenic, lead and chromium found in infant-milk formulae ranged from 5.35-16.51, 0.02-0.79, 0.01-0.21, 0.02-0.30mg/kg respectively. For infant cereals, concentrations were in the ranges of 2.43-64.52, 001-2.42, BDL-0.21, 0.04-2.40mg/kg for Fe, As, Pb and Cr respectively. Cadmium level was below detectable limit except for sample DD (0.02 mg/kg) and FF (0.94mg/kg) for infant-milk formulae and cereal respectively. PAH levels in infant-milk formulae were mostly below detectable limit except for dibenz(a,h)anthracene (0.01mg/kg) in samples AA, BB and CC. Sample DD and EE showed varied concentrations with pyrene (2.31±0.00mg/kg) and Indeno(1,2,3-cd) pyrene (12.48±0.35mg/kg) having the highest values in DD and EE respectively. Cereals NN and CL had no detectable PAHs, while NM, NC and FF showed concentrations ranging from 0.00-1.66, 0.00-2.73 and 0.00-2.70mg/kg respectively. The study suggests that some of the samples (AA, BB, CC, NN and CL) are safe for infant consumption, while others may need further investigation and monitoring to avoid heavy metals and PAHs contamination.

Keywords: *PAHs, Heavy Metals, Infant Formula, Cereals*

1.0 Introduction

During the first few months of life, infants use infant formula to meet their nutritional needs prior to the introduction of essential supplementary feeding. Infant formula is a breast milk substitute (Akpe et al., 2021) and may be enriched with numerous macro and micro nutrients that are crucial for the growth and development of infant, but it is also possible for it to contain pollutants such as heavy metals (Basaran, 2021) and polycyclic aromatic hydrocarbons(PAHs).

According to Bair (2022), food intended for infants and young children may contain some heavy metals. Although heavy metals can affect all humans, but because of their immature development and high food consumption/body weight ratio, children, infants and toddlers are more likely to be negatively affected. Anaemia, nephrotoxicity, developmental and reproductive toxicity and neurotoxic impacts are some of the negative effects of inorganic pollutants exposed to infants and children (Bair, 2022). Wani *et al* (2015) reported that lead can damage the brain and kidneys, and impair IQ. Lead (Pb) forms complexes with oxo-groups in enzymes involved in the synthesis of hemoglobin and metabolism of porphyrin (Ademoroti, 2009). Lead is a toxic metal that poses a risk to the general public's health. Lead could produce reactive oxygen species, the reactive oxygen species created as a result of oxidative stress, negatively impacts the hematological, renal, reproductive and central nervous system (Gagan et al., 2012).

Exposure to high doses of Arsenic can lead to nerve damage, stomach aches, weak immune system, neurodevelopmental issues in children and cardiovascular diseases (Basaran, 2021). Arsenic (As) is one of the most significant heavy metals contributing to both ecological and human health problems (Mazumder, 2008). It exist in the form of sulphides, oxides or as a salt of iron, sodium, calcium, as well as copper and has a semi-metallic property (Singh *et al.*, 2007). Arsenic predominantly affects the sulfhydryl group of cells, it is a protoplasmic poison and can disrupt mitosis, cell respiration and cell enzymes (Singh *et al.*, 2007).

Cadmium (Cd) is an extremely poisonous, non-essential metal similar to Lead. It could cause cell death or stimulate cell proliferation and plays no role in biological diversity in living organisms (Iwegbue *et al.,* 2015). Cd can be harmful to living organisms, even at low concentration (Ambedkar and Muniyan, 2012). According to Edward *et al.* (2013), Cd poisoning in humans can lead to anemia, prostrate dysfunction, hepatic and renal damage, bone disorder and lung cancer. Cadmium can bind to protein rich in cysteine such as metallothionein. The cysteine-metallothionein complex damages the liver and causes hepatotoxicity before it circulates to the kidney where they build up in the renal tissue and results to nephrotoxicity (Genchi et al., 2020). Cadmium has the ability to bind with some amino acid ligands such cysteine, histidine, glutamate and aspartate which can result in iron deficit. Due to their similar oxidation states, Cadmium can replace zinc present in metallothionein and hinder zinc's capacity to scavenge free radicals inside the cells (Jaishankar *et al*., 2014).

Chromium is seen to be a crucial trace element required needed for biosynthesis of glucose tolerance factor and its biological useful form (Cr^{3+}) can be useful for insulin function. On the other hand, Cr (IV) is more toxic. Chromium (Cr) is a metal that can be ingested trough food and is thought to be necessary for many metabolic activities including metabolism of fat and carbohydrates (Suranjana and Manas, 2009). Higher concentration of Cr in the human body could be harmful causing dermatitis and skin cancer as well as kidney, stomach and respiratory tract defects (Olayemi *et al*., 2019). According to Holmes et al (2008), it can also result in foetal fatalities, nasal irritation, nasal septum rupture, hypersensitive reactions, neurological abnormalities and malformations.

Iron on the other hand, is a mineral that is necessary for all forms of life, as it participates in a variety of metabolic processes, oxygen transport, DNA synthesis and electron transport chain. Disorders of iron metabolism encompass a broad spectrum of disease with several clinical manifestation ranging from anemia to iron overload and possibly to neurodegenerative diseases (Abbaspour et al., 2014).

Heavy metals can contaminate the food products through the machines, equipment, various chemicals and packaging materials used in production (Basaran , 2021) . Other routes through which elements and ions may find route into foods include; processing, farming activities and industrial emissions (Ljung *et al*., 2011).

According to US-Department of Health and Human Services (1995), a group of compounds known as Polycyclic aromatic hydrocarbons (PAHs) are formed when coal, oil, gas, wood , waste as well as other organic materials such as tobacco are incompletely burnt. PAH pollutants are extremely harmful to a variety of life forms, including humans. They are also teratogenic, mutagenic, carcinogenic, teratogenic and immune-toxicogenic (Patel et al.,2020). The accumulation of PAHs has been shown in various food matrices, and they can enter the body through the skin, respiratory and swallowing routes. PAH can be formed in a number of foods during packaging, cooking, processing and heat activities. Agricultural products like cereal can also absorb PAH from the environment, particularly if the farms are close to the industrial sites or factories (Moazzon, 2022).

Although infant formula or baby food have many advantages, the presence of contaminants such as heavy metals and polycyclic aromatic hydrocarbons may endanger the health of children. For this reason, the study was conducted to assess the level of contaminants such as heavy metals and polycyclic aromatic hydrocarbons in selected infant formulae and cereals sold in Port Harcourt, Nigeria.

2.0 Methods

2.1 Collection of Sample

A total of five samples of commercially available infant milk formulae and five samples of cereals were gotten from Mile three market, Port Harcourt, Nigeria. Samples were kept in their original packages and were labelled AA, BB, CC,DD and EE for the different infant milk-formulae and Cereals as NN, CL, NM, NC and FF .

2.2Sample Preparation for Metal Determination

Five millilitres (5ml) of nitric acid and 2ml of hydrogen peroxide were added to vessels containing 0.5g of each sample after it had been weighed. Then, vessels were transferred to the Microwave Reaction System (Power: 1400W, Pressure: 20bar, Time: 90 Minute, P-Rate: 0.5 bar/s, TR Lim: 160ºC, T Lime: 190ºC) (Anton Paar, Multiwave 3000, Austria). Following digestion, samples were put into falcon tubes which are polypropylene centrifuge tubes with 50ml capacity and the volume was raised to 10 ml with water.

2.3 Determination of Heavy Metal Ion Concentration

The heavy metal ion concentrations of infant formula were determined using Atomic Absorption Spectroscopy method.

2.4 Determination of PAHs

Ten grams (10g) of the sample was weighed and some portions of anhydrous sodium sulphate was added to dehydrate it. Fifteen millilitres (15ml) of Dichloromethane (DCM) was added to it and stirred. This was then covered and kept for 2 to 4 hours to allow the DCM to extract the PAHs component properly from the sample. The sample was then filtered using whatman filter paper with some portions of anhydrous sodium sulphate so as to completely remove the water content from the sample. This was then allowed to concentrate to about 1ml and then transferred to a Gas Chromatography –Mass Spectrometry (GC-MS) vial bottle for analysis. The analysis was then carried out using Gas Chromatography –Mass Spectrometry (GC-MS).

2.5 Statistical analysis

A one-way analysis of variance (ANOVA) was used to analyse the experiment's data which were presented as mean ± standard deviation. Statistically significant probabilities were considered with a p-value of 0.05 or less ($p<0.05$).

Results

Table 1. Concentration of metals (mg/kg) in infant formulae sold in Port Harcourt

METALS	AA	BB	CC	DD	EE	NIS(2010) MPL
Fe	8.20±0.33[a]	5.35±0.13[bc]	6.26±0.23[ab]	16.13 ± 0.00[d]	16.51±0.00[d]	1.5 mg/kg
As	0.79 ± 0.00[a]	0.74±0.06[a]	0.78±0.00[a]	0.07 ± 0.00[d]	0.02±0.00[d]	0.01mg/kg
Pb	0.02±0.00[a]	0.01±0.00[a]	0.02±0.00[a]	0.15 ± 0.13[d]	0.21±0.02[d]	0.02 mg/kg
Cr	0.02±0.00[a]	0.02±0.00[a]	0.02±0.00[a]	0.22 ± 0.19[d]	0.30±0.03[d]	0.02mg/kg
Cd	BDL	BDL	BDL	0.02 ± 0.00[d]	BDL	0.40 mg/kg

*BDL: Below Detectable Limit

*MPL: Maximum Permissible Limit

Values are expressed as Mean ± Standard Deviation (SD). Values in a row with the same alphabetical superscript do not differ significantly ($p \leq 0.05$).

a. means AA is significantly different from other groups
b. means BB is significantly different from other groups
c. means CCis significantly different from other groups
d. means DDis significantly different from other groups
e. means EE is significantly different from other groups

Table 2. Concentration of metals (mg/kg) in infant cereals sold in Port Harcourt

Metals	NN	CL	NM	NC	FF	NIS (2010) MPL
Fe	15.69±0.03[a]	2.43±0.35[b]	47.03±1.21[c]	40.44±0.63[d]	64.52 ± 1.26[e]	1.5 mg/kg
As	0.03±0.00[a]	0.08±0.00[a]	0.04±0.00[a]	0.01±0.00[a]	2.42 ± 0.08[e]	0.01mg/kg
Pb	0.17±0.00[a]	0.14±0.00[a]	0.21±0.00[a]	0.07±0.00[a]	BDL	0.02 mg/kg
Cr	2.40±0.00[a]	1.04±0.00[b]	0.81±0.00[c]	0.44±0.00[d]	0.04 ±0.00[e]	0.02mg/kg

Cd	BDL	BDL	BDL	BDL	0.94 ± 0.03^{e}	0.40 mg/kg

*BDL: Below Detectable Limit

*MPL: Maximum Permissible Limit

Values are expressed as Mean ± Standard Deviation (SD). Values in a row with the same alphabetical superscript do not differ significantly ($p \leq 0.05$).

a means NBN is significantly different from other groups at p≤0.05
b means CLC is significantly different from other groups at p≤0.05
c means NBM is significantly different from other groups at p≤0.05
d means NLC is significantly different from other groups at p≤0.05
e means FSG is significantly different from other groups at p≤0.05

TABLE 3 CONCENTRATION OF POLYCYCLIC AROMATIC HYDROCARBONS (mg/kg) IN INFANT MILK FORMULAE.

Parameters	AA	BB	CC	DD	EE
Naphthalene	0.00±0.00	N. D	0.00±0.00	0.16±0.05^{a}	0.12±0.01^{a}
Acenaphthylene	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.83±0.01^{b}	0.00±0.00^{a}
Acenaphthene	0.00±0.00^{a}	N. D	0.00±0.00^{a}	0.09±0.00^{a}	0.39±0.01^{e}
Fluorene	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.16±0.00^{d}	3.05±0.01^{e}
Phenanthrene	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	1.23±0.01^{d}	2.16±0.02^{e}
Anthracene	N.D.	0.00±0.00^{a}	N.D.	0.42±0.00^{d}	1.14±0.13^{e}
Fluoranthene	N.D.	0.00±0.0^{b}	N.D.	0.94±0.01^{d}	2.16±0.12^{e}
Pyrene	0.00±0.00^{a}	N. D	0.00±0.00^{a}	2.31±0.00^{d}	1.62±0.00^{e}
Benzo(a)anthracene	0.00±0.00^{a}	N. D	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}
Chrysene	N.D.	N. D	N.D.	0.10±0.00^{d}	0.07±0.00^{e}
Benzo(b)fluoranthene	N.D.	N. D	N.D.	0.49±0.05^{d}	0.00±0.00^{e}
Benzo(k)fluoranthene	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.04±0.00^{d}	0.00±0.00^{a}

Benzo(a)pyrene	0.00±0.00[a]	0.00±0.00[a]	0.00±0.00[a]	0.14±0.00 [d]	0.86±0.00 [e]
Dibenz(a,h)anthracene	0.01±0.00[a]	0.01±0.00[a]	0.01±0.00[a]	0.26±0.03 [d]	0.32±0.10 [d]
Indeno(1,2,3-cd)pyrene	0.01±0.00[a]	0.00±0.00[a]	0.00±0.00[a]	1.19±0.12 [d]	12.48±0.35 [e]
Benzo(g,h,i)pyrene	0.01±0.00[a]	.00±0.00[a]	0.00±0.00[a]	0.13±0.01 [d]	0.55±0.09 [e]

ND not detected

Values are expressed as mean ± standard deviation (n=3). Values with same alphabetical superscript within a row do not differ significantly at p≤0.05

a. means AA is significantly different from other groups
b. means BB is significantly different from other groups
c. means CCis significantly different from other groups
d. means DDis significantly different from other groups
e. means EE is significantly different from other groups

Table 4 Concentration of Polycyclic Aromatic Hydrocarbons (mg/kg) in Infant Cereals Sold in Port Harcourt**.**

Parameters	**NN**	**CL**	**NM**	**NC**	**FF**
Naphthalene	N. D	N. D	0.25±0.13[c]	0.41±0.00[d]	0.08±0.01[e]
Acenaphthylene	0.00±0.00 [a]	0.00±0.00 [a]	1.66±0.02 [c]	0.03±0.00[d]	0.00±0.00 [a]
Acenaphthene	N. D	N. D	0.04±0.00 [c]	1.44±0.03[d]	0.01±0.00 [e]
Fluorene	0.00±0.00 [a]	0.00±0.00 [a]	1.50±0.00 [c]	2.03±0.00[d]	1.04±0.01 [e]
Phenanthrene	0.00±0.00 [a]	0.00±0.00 [a]	1.14±0.00 [c]	0.00±0.00[a]	0.73±0.00 [e]
Anthracene	0.00±0.00 [a]	0.00±0.00 [a]	0.63±0.00 [c]	2.73±0.00[d]	0.52±0.00 [e]
Fluoranthene	0.00±0.00 [a]	0.00±0.00 [a]	0.94±0.00 [c]	0.18±0.00[d]	0.25±0.00 [e]
Pyrene	N. D	N. D	0.00±0.00 [c]	0.70±0.00[d]	0.95±0.00 [e]
Benzo(a)anthracene	N. D	N. D	0.59±0.01 [c]	0.57±0.00[c]	0.00±0.00 [e]
Chrysene	N. D	N. D	0.26±0.02 [c]	1.19±0.00[d]	0.44±0.00 [e]

Benzo(b)fluoranthene	N. D	N. D	1.07±0.00^{c}	0.09±0.01^{d}	0.00±0.00^{e}
Benzo(k)fluoranthene	0.00±0.00^{a}	0.00±0.00^{a}	0.51±0.01^{c}	0.04±0.00^{d}	0.00±0.00^{a}
Benzo(a)pyrene	0.00±0.00^{a}	0.00±0.00^{a}	0.00±0.00^{a}	0.10±0.00^{c}	0.25±0.00^{d}
Dibenzo(a,h)anthracene	0.00±0.00^{a}	0.00±0.00^{a}	0.41±0.01^{c}	0.36±0.02^{c}	0.07±0.02^{e}
Indeno(1,2,3-cd)pyrene	N. D	N. D	0.08±0.01^{c}	0.48±0.04^{d}	2.70±0.08^{e}
Benzo(ghi)perylene	N. D	N. D	0.01±0.00^{c}	0.04±0.00^{c}	0.12±0.02^{d}

Values are expressed as mean ± standard deviation (n=3)
Values with same alphabetical superscript within a row do not differ significantly at $p \leq 0.05$

a means NN is significantly different from other groups at $p \leq 0.05$
b means CL is significantly different from other groups at $p \leq 0.05$
c means NM is significantly different from other groups at $p \leq 0.05$
d means NC is significantly different from other groups at $p \leq 0.05$
e means FF is significantly different from other groups at $p \leq 0.05$

3.0 Discussion

Due to the damage that heavy metal contamination has done to the environment as a whole, it has become a prevalent concern in recent years to find heavy metals in many useful and consumable items. Humans, especially infants are at risk of health problems as a result of food contaminated with heavy metals (Asomugha *et al*., 2016).

The result of the analysis presented on Table 1 above showed the concentrations of the heavy metals in the infant-milk formulae sold in Port Harcourt. The result revealed that the concentration of cadmium was below detectable limit for all the samples except DD (0.02 ± 0.00 mg/kg) and this was below the permissible limit for NIS (2010) of 0.40 mg/kg. Thus implying that its amount in the infant-milk formulae is insignificant and negligible at the moment. The iron content (Fe) of the selected infant formulae varied significantly ($p<0.05$) in most of the samples. Sample BB had the lowest concentration of iron (5.35±0.18mg/kg), whereas Sample DD (16.13 ± 0.00 mg/kg) and EE (16.51±0.00 mg/kg) was significantly higher than the other samples. The concentration of arsenic showed no significant difference in Sample AA (0.79±0.00 mg/kg), Sample BB (0.74±0.09 mg/kg) and CC (0.79±0.00 mg/kg). However, the values in Sample DD (0.07 ± 0.00mg/kg) and EE (0.02±0.00 mg/kg) were significantly low compared to the values for AA, BB, and CC. Lead concentration was significantly low in Sample AA (0.02±0.00 mg/kg), BB (0.01±0.00 mg/kg) and CC (0.02±0.00 mg/kg) when compared with DD (0.15 ± 0.13 mg/kg) and EE (0.21±0.02 mg/kg). The concentration of Chromium was the same (0.02±0.00 mg/kg) in the sample AA, BB and CC whereas DD (0.22 ± 0.19 mg/kg) and EE (0.30±0.03 mg/kg) was significantly different from the others. From the results obtained, the concentration of the heavy metals studied across the brands of infant-milk formulae was in the order: Iron > Arsenic > Chromium > Lead > Cadmium. This result is in agreement with previous works. Su *et al* (2020) worked on the content and dietary exposure assessment of toxic elements in infant formulae from the Chinese market reported that Cr, As, Cd and Pb to be in the ranges of 2.51-83.80,0.89-7.87, 0.13-3.58 and 0.36-5.57ug/kg. Also Basaran (2021) noted that the average concentration of Pb, Cd, and As on infant formulae sold in Turkey were 0.025,0.002 and 0.021mg/kg. Akpe *et al* (2021) in their work on infant nutrition formula in Cross Rivers State, Nigeria found that the concentration of arsenic was<0.001mg/kg, Cd , Cr and Pb were within the ranges of 0.010-0.052,0.002-0.04,0.080-0.014 mg/kg respectively.

Table 2 shows the concentration of heavy metals in infant cereals sold in Port Harcourt. The concentration of iron was significantly different in the order FF (64.52 ± 1.26 mg/kg) > NM (47.03±1.21 mg/kg) > NC (40.44±0.63 mg/kg) > NN (15.69±0.03 mg/kg) > CL (2.43±0.35 mg/kg). The concentration of Arsenic was significantly higher in FF while the other groups showed no significant difference. Furthermore, Pb was below detectable limit (BDL) in FF while the other groups had a range of 0.07±0.00 to 0.21±0.00 mg/kg , although there was no significant difference. Cd concentration was below detectable limit for all the samples except for FF which had 0.94 ± 0.03 mg/kg. And Cr was within the range of 0.04-2.40mg/kg. There was variation in the concentration of heavy metals when compared to the works of Amarh et al., (2023) who did a work on health risk assessment of some selected heavy metals in infant food sold in Wa, Ghana, the concentration (mg/kg) of As, Cd, Cr and Pb was 0.006-0.057,0.043-0.064,0.013-0.33 and 0.061-0.368 respectively.

The levels for Pb gotten from this study were lower than the permissible limit of 1.0ppm set by the United States Food and Drug Administration (USFDA) for food primarily consumed by children (USFDA 2006). As a result, our investigation showed that in these samples' Pb concentrations are below the levels allowed in samples of infant food. However, given that infants are more vulnerable to the effects of lead exposure than adults are, lead contamination in infant formula/food needs to be frequently monitored (Hande *et al.*, 2014).

The concentration of PAHs in infant milk-formulae sold in Port Harcourt is shown on Table 3. Most samples had a concentration of 0.00mg/kg with the exception of Dibenz(a,h)anthracene which had a 0.01 for all the samples and Indeno(1,2,3-cd)pyrene ; Benzo(g,h,i)pyrene which had 0.01mg/kg for sample AA only and not detected in other samples BB and CC. Samples DD and EE had varied concentration of PAHs with Indeno(1,2,3-cd)pyrene(12.48±0.35mg/kg) been the highest in sample EE and pyrene(2.31±0.00mg/kg) was the highest in DD . The concentration was within the permissible range of 1µg/kg in baby food set by European Union Regulation (Commission, 2015) for all samples except DD and EE. Consequently, it is safe to consume these infant milk-formulae except for DD and EE which needs to be properly monitored .

Table 4 shows the result of PAHs (mg/kg) in infant Cereals sold in Port Harcourt**.**. There was no PAHs found on baby cereal NN and CL showing no PAHs toxicity for these selected cereals. Whereas sample NM, NC and FF had some levels of PAHs with highest values found in Acenaphthylene (1.66±0.02) , anthracene(2.73±0.00) and Indeno(1,2,3-cd)pyrene (2.70±0.08) for NM, NC and FF respectively. The findings of this study agreed with those of Iwegbue *et al.* (2014) [for some of the samples of this study], who reported that the estimated dietary exposure to PAHs by infant through consumption of these infant formulas was generally low. In 2014, Han et al., stated that the PAHs concentration in µg/kg for infant formulae, follow-up and special formula was in the ranges; BaA(0.00-0.003), BbF(0.017-0.085), BkF(0.033-0.058), BaP (0.022-0.056) while Cry, DahA and Icdp was 0.00 for all the samples. In another study by Cai et al., (2020),they had a PAH_4 range of 0.1 -0.87 µg/kg on their work on the detection , risk assessment and survey of four PAH markers in infant formula powder. Similar works by Moazzan et al., (2022), showed that benzo[a]pyrene was 0.29 ± 0.14µg/kg was lower than the USEPA standard level of 1µg/kg in baby food. The result thus, indicates that there are no health risks at the moment for the infants who consume some of these brands of infant formulae and cereals.

Conclusion

The concentration of Cadmium (Cd), Iron (Fe), Arsenic (As), Lead (Pb) , Chromium (Cr) and PAHs were assessed in commonly sold infant milk formulae and cereals in Port Harcourt. The study revealed presence of some heavy metals in these products used in Nigeria. However, due to the low levels of heavy metal concentration in some of the samples, there is currently no apparent health risk for the infant population. PAHs levels in both infant milk formulae and cereals were generally very low with most of them having a 0.00mg/kg concentration, other than Dibenz(a,h)anthracene which had a consistent 0.01mg/kg across all samples(AA, BB and CC) and Indeno(1,2,3-cd)pyrene ; Benzo(g,h,i)pyrene which was at 0.01mg/kg for sample AA only and undetected in others. A notable concern was the elevated value of 12.48±0.35mg/kg of Indeno(1,2,3-cd)pyrene found in sample EE. Cereals NM, NC and FF had varied concentrations of these PAHs. The findings underscore the need for ongoing regulatory measures in the processing and consumption of these products to prevent contamination and potential health risks.

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