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Organochlorine compounds in bovine milk from the state of Mato Grosso do Sul – Brazil

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HIGHLIGHTS

- In samples of milk produced in Mato Grosso do Sul – Brazil found residues of organochlorine.
- Of the 100 samples of milk analyzed, 90% contained organochlorine.
- Aldrin present in 45% of the samples.
- ∑DDT present in 36% of the samples.

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ABSTRACT

Organochlorines are highly hydrophobic, synthetic organic pollutants that accumulate in the environment and in food webs. The primary route of human exposure to organochlorines is through food-mainly fat-rich food of animal origin such as meat, fish, and dairy products. Here we determined the presence and concentration of organochlorine residues in pasteurized milk from Mato Grosso do Sul, Brazil, to monitor consumer exposure to these contaminants. Organochlorine pesticides in milk samples were analyzed using solid phase extraction in octadecyl silica-prepacked columns and identified by gas chromatography using an electron capture detector. Of the 100 composite samples analyzed, more than 90% contained residues of organochlorine pesticides: aldrin was present in 44% of the samples, followed by ∑DDT (36%), mirex (34%), endosulfan (32%), chlordane (17%), dicofol (14%), heptachlor (11%) and dieldrin (11%). Compared to the values established by law, the concentration of the compounds in some samples was above the reference values. Given the importance that milk and its products have in the human diet, it is essential to know whether the levels of pesticide residues are kept well below the recommended levels to minimize the risk to human health.

1. Introduction

Organochlorines are highly toxic, persistent organic pollutants (POPs) with adverse effects to the environment and human health. Due to their lipid solubility and slow biotransformation, organochlorines can accumulate in animal adipose tissues via the food web (Gasull et al., 2010).

A study carried out in Spain indicated the affinity of organochlorinated compounds for fats, showing evidence of increasing contamination through the food chain (Costabeber, 1999).

Indeed, the primary route of human exposure to organochlorines is through food, especially foods of animal origin such as beef, fish and dairy products that are rich in fat. For many populations, these foods represent an important part of the daily diet. Previous studies demonstrated that animal-origin food is responsible for more than 90% of the average human intake of organochlorine compounds and polychlorinated biphenyls (PCBs) (Dirtu and Covaci, 2010). However, the general population may also be exposed to pesticides through dermal exposure after domestic use, in public places (parks, auditoriums), or inadvertently through inhalation during application. Thus, exposure is often chronic in nature, occurring over a lifetime.

The mechanism underlying the toxicity of organochlorines involves the induction of enzyme activity through free radicals, ultimately affecting the immune response, the reproductive and neurological systems, lipid metabolism, and the transport of

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vitamins and glucose. Additionally, some of these compounds are mutagenic, teratogenic, and carcinogenic not only in humans, but also in biotic communities with different levels of sensitivity (Castilla-Pinedo et al., 2010).

As already emphasized, the presence of chlorine and other POPs is positively correlated with damage to human health and the contamination of environmental matrices. (Sharp et al., 1986; Hashimoto, 1990; Safe, 1990; Wolff et al., 1993; Ritter, 1997; Serrano et al., 2003; Dai et al., 2011; Gasull et al., 2011; Lee et al., 2011; Neta et al., 2011; Stoker et al., 2011).

POPs have been banned from and/or are restricted in most developed countries. However, POPs are still occasionally used in developing countries because of their low cost and effectiveness against pests. Several studies worldwide have found residues of chlorinated contaminants in various types of food, including fish, milk, dairy products, fruits, vegetables, meat, and poultry (Heck et al., 2007; Ciscato et al., 2009; Schecter et al., 2010; Bulut et al., 2011; Cascaes, 2011;Bayat et al., 2010).

In Brazil, pesticides are increasingly marketed, with 1.06 million tons of pesticides sold in 2009 alone (7.6% increase compared to 2008) (SINDAG, 2010). The National Union for Agriculture Defense Products considers Brazil the largest market for these products, with 107 companies authorized to register their chemical compounds, accounting for 16% of the world market (ANVISA, 2009; Câmara dos Deputados do Brasil, 2011). According to the Health Surveillance Agency, ANVISA (2009), Brazil is already the largest consumer of pesticides in the world, with 700,000 tons in the country. The use of pesticides in the states of Espirito Santo, Goiás, Mato Grosso do Sul, Minas Gerais, São Paulo, Paraná, Santa Catarina, Rio Grande do Sul, and Tocantins accounts for 70% of the total amount used in the country (Souza, 2006).

In 1985, organochlorine pesticides were banned in Brazil through Federal Decree No. 329/85, from the Ministry of Agriculture. Endosulfan is currently allowed for coffee, cocoa, cotton, and soy crops, but in 2013, its use will also be prohibited.

Organochlorines are a source of global contamination, putting the survival of several species at risk and causing serious human health problems. Many countries still allow the excessive use of these pesticides, and even in the countries where these substances are prohibited, it is possible to find them on the black market (Flores et al., 2004).

The use of pesticides acquired illegally from neighboring countries has been reported by the Brazilian press, especially in some states such as Rio Grande do Sul, Paraná, and Mato Grosso do Sul, due to the proximity with these countries.

The aim of this study was to evaluate the presence and concentration of organochlorine residues in pasteurized milk produced for human consumption in the state of Mato Grosso do Sul (Brazil).

2. Materials and methods

2.1. Reagents

All solvents used for pesticide residue analysis were of purity grade; pesticide standards were highly pure (>98%; Accu Standard).

Pesticides analyzed were a-chlordane, g-chlordane, a-HCH, b-HCH, HCB, aldrin, dieldrin, endrin, dicofol, endosulfan I, endosulfan II, heptachlor epoxide A, heptachlor epoxide B, heptachlor, methoxychlor, mirex, o,p′-DDD, p,p′-DDD, o,p′-DDE, p,p′-DDE, o,p′-DDT, p,p′-DDT, pentachloroanisole, and *trans*-nonachlor.

2.2. Sample collection

Milk samples were collected at three different periods (July 2009, December 2009/January 2010, and July 2010) in 20 locations (dairies) distributed across micro-geographic regions (MGRs) as defined by the Brazilian Institute of Geography and Statistics (IBGE): MGR 02 (Dois Irmãos), MGR 03 (São Gabriel, Rio Verde, and Coxim), MGR 04 (Campo Grande, Bandeirantes, Camapuã, and Sidrolândia), MGR 06 (Paranaíba and Aparecida do Tabuado), MGR 09 (Caracol, Guia Lopes, Bodoquena, and Bela Vista), MGR 10 (Dourados, Glória de Dourados, and Nova Alvorada), and MGR 11 (Iguatemi, Paranhos, Mundo Novo, and Ivinhema) (Fig. 1).

In each dairy, two samples per collection time were collected, except in the third collection, in which only one sample was taken. Thus, a total of 100 samples of pasteurized milk were collected from the 20 dairies selected.

The milk samples, collected by health surveillance agents from the original distribution packages, are representative of various locations (many of them small farms) around one dairy to which products are delivered for pasteurization and distribution. Therefore, these are composite samples.

The samples were transported in refrigerated coolers. Glass jars previously washed with neutral Extran and rinsed with acetone and *n*-hexane were used to store the samples at approximately −20 °C until analysis in the Laboratory of Toxicology Studies of the Center of Occupational Health and Human Ecology (CESTEH/FIOCRUZ).

2.3. Sample preparation

The samples were thawed at room temperature and aliquoted in 1-mL volumes. The aliquots were placed in a water bath at 37 °C ± 2 °C for about 20 min, after which 10 mL of ethyl acetate:methanol:acetone 2:4:4 was added. The mixture was then vortex-mixed for 1 min, sonicated for 20 min, and centrifuged for 15 min at approximately 2000 rpm. The supernatant was moved to a fresh tube, and 10 mL of water was added.

2.4. Solid phase extraction and cleanup

Organochlorine pesticides in milk samples were analyzed following the method described by Stevenson (1991) and modified by Mesquita (2011).

Briefly, octadecyl silica (C_{18}) SPE PACK™ columns were primed twice with 1 mL of *n*-hexane, twice with 1 mL of ethyl acetate, twice with 1 mL of methanol, and twice with 1 mL of distilled water using a vacuum. The column was not allowed to dry and a small volume of solvent was kept above the solid phase.

The supernatants obtained in Section 2.3, containing both organic phase and water, were passed through the pre-conditioned column at a flow rate of 3–5 mL min^{-1}. The column was then washed twice with 1 mL of 75% H_2O with 25% acetonitrile. Subsequently, the column was dried under vacuum (−15 in Hg) for 30 min. The pesticides retained in the column were eluted with 1 mL of *n*-hexane.

The extract was cleaned through a Florisil® column preconditioned with 10 mL of dichloromethane, 10 mL of ethyl acetate, 10 mL of a mixture of 15% acetone in petroleum ether, and 10 mL of hexane.

The 1-mL volume collected from the C_{18} column was eluted with 10 mL of hexane and then with 5 mL of a mixture of 15% acetone in petrol ether. The total volume of 15 mL collected was evaporated to 0.1 mL under commercial nitrogen atmosphere, to which 10 μL of internal standard (octachloronaphthalene [OCN]) at 50 μg mL^{-1} was added. During evaporation, the tube was rinsed four times in a sequence with approximately 10 mL, 5 mL, 1 mL, and 0.5 mL of *n*-hexane.

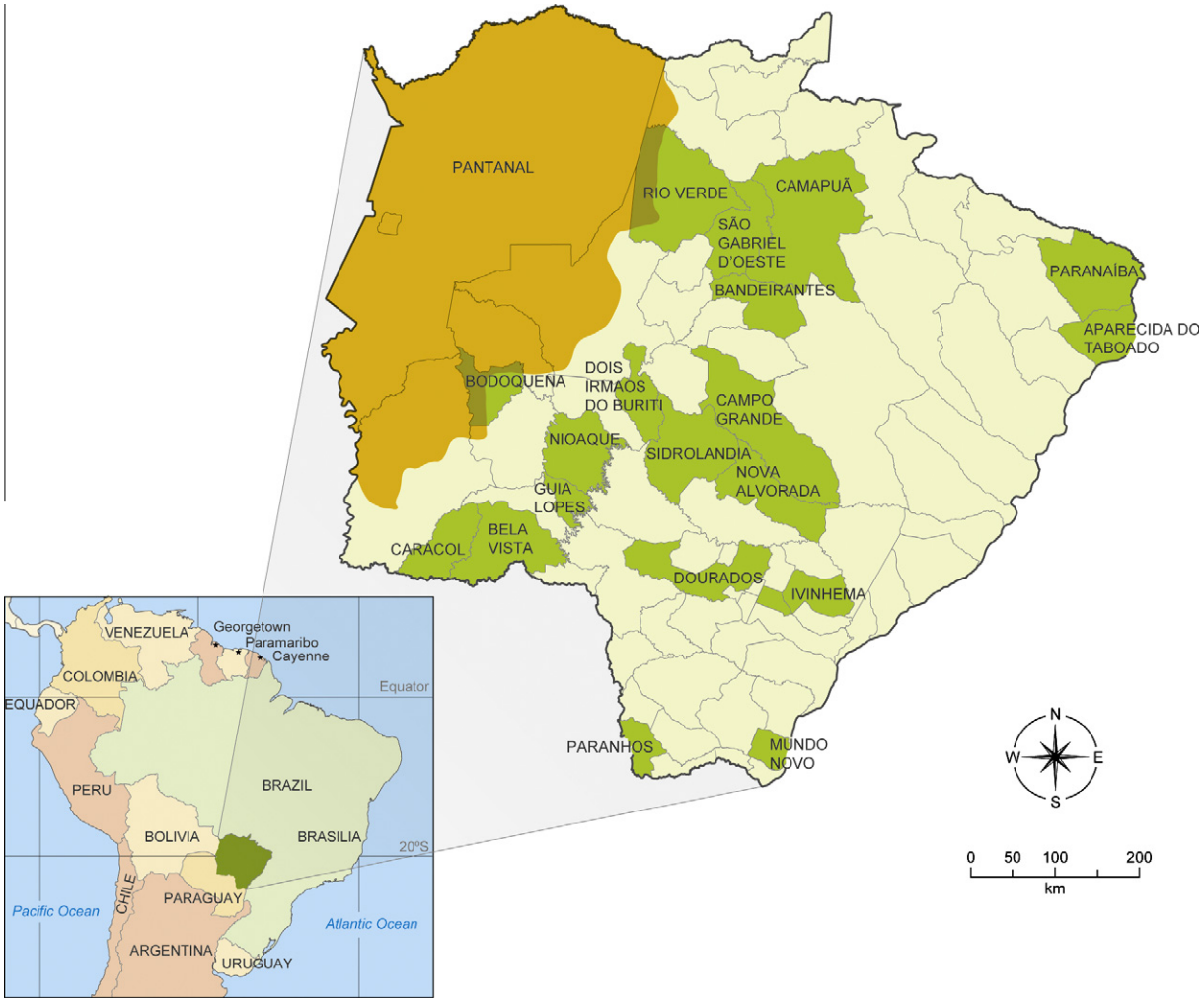

Fig. 1. Location of the study area. Dark gray-shaded areas indicate the regions where pasteurized bovine milk samples were collected.

2.5. Chromatographic analysis

Chromatographic analysis was performed by gas chromatography with electron capture detection (Agilent Technologies model 6890). Injector conditions were as follows: splitless injection, pulse pressure of 25 psi until 0.5 min, temperature of 240 °C, and injection volume of 2 μL. Ultrapure nitrogen was used in the oven and make-up. We used an HP-5 capillary column (5% diphenyl, 95% dimethylpolysiloxane, 30 M, 320 μm inner diameter, and 0.2 μm film thickness) at a column flow of 1 mL min^{-1} and temperature of 50 °C for 10 min with the following sequence: rinsed at 7 °C min^{-1} until 170 °C, maintained for 10 min, rinsed at 1.5 °C min^{-1} until 230 °C, maintained for 10 min, and finally rinsed at 50 °C min^{-1} until 280 °C, maintained for 10 min. Total run time was 68.14 min. Make-up flow was 60 mL min^{-1}, and the detector temperature was 300 °C.

Pesticide quantification was performed by internal standardization, taking into account a mixture of standards with known concentrations of approximately 10 ng mL^{-1}. Identification of peaks was made by injection in a different column (35% diphenyl, 65% dimethylpolysiloxane) and comparison with standards under the same chromatographic conditions.

2.6. Determination of fat content

For the quantification of fat content, 8 mL of a mixture of hexane:acetone 1:1 was added to 2 mL of milk sample. The mixture was vortex-mixed for 1 min and placed in an ultrasonic bath for 20 min, after which it was centrifuged at 4000 rpm ± 100 rpm for 15 min. The previously collected supernatants were weighed on an analytical balance. The extraction was repeated once more, and the supernatants were placed in the same tube. The solvent was evaporated under commercial nitrogen atmosphere until dryness, and the tube was weighed. The final concentration of pesticide was expressed in ng g^{-1} of fat.

2.7. Analytical quality control

An analytical quality control method was previously validated under laboratory-operating conditions using parameters recommended by the Instituto Nacional de Metrologia, Qualidade e Tecnologia do Brasil (Inmetro). Linearity studies were performed for all pesticides in the range of 1.25–20 μg L^{-1}. The *r*-values ranged from 0.9899 to 0.9991, showing a linear relationship between the detector response and five different concentrations (1.25, 2.5, 5, 10, and 20 μg L^{-1}), with five curves for each pesticide. The recovery was tested with fortification of cow milk at three different concentration levels (1.25, 5, and 20 μg L^{-1}), with mean values ranging from 70.1% to 102%. The coefficients of variation between the fortified replicates ranged from 1.2% to 4%. The method's quantification limit ranged from 0.02 to 2.15 μg L^{-1}.

For each batch of samples, a sample of low-fat bovine milk was fortified with a mixture of pesticides at a concentration of 5 μg L^{-1}. The values of the internal standard between the original and

fortified samples were compared to evaluate any deviation in the analytical method.

3. Results and discussion

Of the 100 composite samples analyzed, more than 90% contained residues of organochlorine pesticides (Table 1). Aldrin was present in 44% of the samples, followed by ∑DDT (36%), mirex (34%), endosulfan (32%), chlordane (17%), dicofol (14%), heptachlor (11%) and dieldrin (11%). In some of the samples, the concentration of the compounds was above the reference values (MLRs). (Brasil, 1999; EC, 2005; Codex Alimentarius, 2010). The ∑DDT concentrations were below the established MLR. Forty-seven percent of the samples contaminated with chlordane had values exceeding the MLR (2.0 ng g^{-1} of fat) (Table 1). Fifty percent of the samples were contaminated with aldrin/dieldrin, and 14% of them had values above the reference values (6.0 ng g^{-1} of fat). For Heptachlor, eleven samples (11%) were contaminated, and 30% of them presented values above the MRL (6.0 ng g^{-1} of fat) (Table 1). Heptachlor is probably the most persistent toxic substance commonly used in Brazil. Between 1961 and 1982, 4.7 tons were imported, and from 1989 to July of 2003, the importation rate was 1.7 thousand. However, there is no information regarding the existence of any national production (Almeida, 2007). Methoxyclor, β-HCH and o,p′-DDT compounds were not identified in any of the analyzed samples.

The presence of organochlorine contaminants in food, biological and environmental matrices is already known. Few studies have investigated organochlorated pesticide residues in milk in Brazil, and there are no studies regarding organochlorinated contaminants in bovine milk in the region where this research was conducted. The few studies in the literature evaluated human milk and water.

Because the economy of Mato Grosso do Sul (Brazil) is based on agriculture and cattle breeding, with a focus on meat and milk production, research about the content of persistent organic pollutants in animal products produced locally is important. Even though this research does not account for the entire region, the results are meaningful because this is one of the first studies to describe the concentration of these kinds of contaminants in bovine milk produced locally. A similar study was conducted in the south of Brazil in 2007. The presence of organochlorinated pesticides and polychlorinated biphenyls were investigated in pasteurized and sterilized milk from Rio Grande do Sul (Brazil) (Heck et al., 2007). In that study, all samples of bovine milk presented at least one compound. The isomer p,p′-DDE (11.9 ng g^{-1}) was mainly responsible for ∑DDT values, indicating 20.1 ng g^{-1} of fat, above the value observed in this study (16.71 ng g^{-1} of fat). Regarding the compound HCH, the concentration values found in Mato Grosso do Sul were the same as the values observed in the study conducted in the south of the country. Nevertheless, the concentrations of aldrin and o,p′-DDD in this study were higher (Table 1).

In a study that analyzed cheese produced in the south of Brazil, HCH, HCB, lindano, o,p′-DDD and p,p′-DDD compounds were identified in 100% of the samples. The levels of ∑DDT were equal to the ones identified in the bovine milk studied (16.7 ng g^{-1} of fat). The levels of HCH and aldrin/dieldrin were lower than the ones found in the milk produced in Mato Grosso do Sul (0.9 and 7.9 ng g^{-1} of fat, respectively) (Santos et al., 2006).

Recently, a study was performed regionally at the Federal University of Mato Grosso, Brazil (a region close to Mato Grosso do Sul) finding organochlorine levels above the values of this study. Indeed, the former revealed that the breast milk of residents of the city of Lucas do Rio Verde was contaminated with DDE. All samples (n = 62) were contaminated by p,p′-DDE (0.012 ng g^{-1} fat), 44% for β-endosulfan (0.00061 ng g^{-1} fat) and 13% p,p′-DDT (0.012 ng g^{-1}

Table 1
Mean OCPs residues in pasteurized milk samples (n = 100).

Compounds	Mean (standard deviation) (ng g^{-1} fat)	Range (ng g^{-1} fat)	Incidence (%)	MRL[b] (ng g^{-1} fat)	MRL[c] (ng g^{-1} fat)
∑ **HCH**	1.61(±1.01)	0.45–2.34	3%	4	–
a-HCH	1.61(±1.01)	0.45–2.34	3%	–	4
b-HCH	0(±0)	0.0–0.0	–	–	3
HCB	0.52(±0.08)	0.45–0.64	5%	10	10
Dicofol	5.11(±1.7)	2.75–9.61	14%	100	20
∑ **Heptachlor**	3.05(±2.0)	1.22–6.02	11%(30%)[a]	6	4
Heptachlor Epoxy B	3.05(±0.0)	3.05–3.05	3%	–	–
Heptachlor Epoxy A	1.53(±0.3)	1.23–2.15	7%	–	–
Heptachlor	1.8(±0.79)	1.22–3.57	7%	6	6
∑ **DDT**	3.74(±3.19)	0.58–16.72	36%	50	40
o,p′-DDE	1.82(±1.26)	0.58–5.45	20%	–	–
p,p′-DDE	6.67(±0.0)	6.67–6.67	1%	–	–
o,p′-DDD	3.38(±2.18)	1.02–10.96	26%	–	–
p,p′-DDD	2.32(±0.0)	2.32–2.32	1%	–	–
o,p′-DDT	0.0(±0.0)	0.0–0.0	–	20	20
p,p′-DDT	1.46(±0.0)	1.46–1.46	1%	20	20
Aldrin + Diedrin	5.62(±1.46)	0.13–14.73	50% (4%)[a]	6	6
Dieldrin	4.39(±3.98)	0.98–14.73	11% (18%)[a]	6	6
Aldrin	0.74(±0.48)	0.1–1.86	44%	6	–
∑ **Endosulfan**	2.4(±2.57)	0.28–12.2	32%	–	50
Endosulfan I	1.95(±0.98)	1.00–4.03	12%	10	10
Endosulfan II	2.23(±3.0)	0.13–12.2	24%	–	–
∑ **Clordane**	2.78(±1.58)	1.49–6.57	17% (47%)[a]	2	2
a-Clordane	2.69(±1.29)	1.49–5.98	12% (58%)[a]	2	2
g-Clordane	2.14(±0.8)	1.35–3.84	7% (29%)[a]	2	2
Trans-nonachlor	2.05(±0.83)	0.93–3.27	7%	–	–
Endrin	3.91(±0.0)	3.91–3.91	1% (100%)[a]	0.8	0.8
Metoxychlor	0.0(±0.0)	0.0–0.0	–	–	10
Mirex	6.32(±3.44)	1.24–13.77	34%	–	–

[a] Percentage of samples that showed values above the reference value (Brasil, 1999; Codex Alimentarius, 2010).
[b] Brasil (1999), Codex Alimentarius (2010).
[c] EC (2005).

fat). Further, it showed that 100% of the samples were contaminated with at least 1 pesticide, with residues of DDE, a derivative of the DDT pesticide banned from Brazil for more than 10 years, being present in all cases. Of the residues found, most are organochlorine substances of high toxicity, dispersibility, and resistance both in the environment and the human body (Palma, 2011).

Another study conducted in 31 water samples collected in the district of Culturama, municipality of Fátima do Sul, State of Mato Grosso do Sul, Brazil during the months of September to November 2008, revealed similar data. Residues of organochlorine compounds were found in 16 of the 31 samples analyzed. Of the 18 organochlorine pesticides studied, seven were detected and four were quantified. Pesticide concentrations ranged from 0.0019 to 0.153 ng mL^{-1}. The percentage of samples contaminated with ∑DDT was 38.7% (at concentrations between 0.0019 and 0.009 ng mL^{-1}) and of endrin 3.4% (0.153 ng mL^{-1}). Compared to this study, the concentrations were few higher only for endrin (0.150 ng mL^{-1}) (Prates et al., 2011).

A general overview of these contaminants in food and environmental matrices throughout the country has not yet been established. The results obtained vary according to the particularities of each region. In 2010, ANVISA, through its Program for the Analysis of Pesticide Residues in Food (PAPRF), measured the concentration of pesticide residues in the 18 most consumed foods in Brazil. The sampling took place in several states, including Mato Grosso do Sul. Of the 18 foods investigated, 13 of them (72%) contained medium to very high concentrations of pesticides (ANVISA, 2010). From a total of 2488 samples, 28% were actually considered unsatisfactory because of the presence of unauthorized products or permitted products above reference values (ANVISA, 2010). Similarly, and importantly, all of the organochlorine residues analyzed in the present study, except endosulfan, which will be banned in 2013, are unauthorized in Brazil.

The occurrence of various types of organochlorinated compounds in the blue shark (*Prionace glauca*) in the Brazilian southern coast was observed. The concentration of DDT ranged from 8.72 to 51.36 ng g^{-1} of fat. In general, the concentration of compounds was correlated with the total length of the animal, which shows a possible accumulation of pollutants in the tissues as the animals grow older (Cascaes et al., 2011). Another study carried out in the region of Rio Madeira, located in the Brazilian Amazonian basin, analyzed the presence of p,p′-DDT and its metabolites, p,p′-DDE and p,p′-DDD in 69 samples of human milk. Until the 1990s, houses situated along Rio Madeira were inundated with DDT. This region is known for a high incidence of malaria. The results showed higher contamination with DDT and its metabolites than in the bovine milk studied, ranging from 25.4 to 9361.9 ng of ∑DDT g^{-1} of lipid (median = 369.6 ng of ∑DDT g^{-1} of lipid) (Azeredo et al., 2008). The authors indicated that the milk contamination can be associated with the population's eating habits, which rely on fish from this river.

Results from research performed in Cidade dos Meninos, Rio de Janeiro (Brazil), indicate the contamination of many environmental compartments; in several concentrations, there is a mixture of isomers of hexachlorocyclohexane (HCH), dichlorodiphenyltrichloroethane (DDT) and its metabolites, trichlorophenol (TCP), trichlorobenzene (TCB), polychlorinated dibenzodioxins (PCDD) and polychlorinated dibenzofurans (PCDF). The food chain represents the main means through which the population is exposed to contamination. The foods of animal origin are the most contaminated—especially chicken eggs and cow milk (Brasil, 2002). Moreover, in São Paulo (Brazil), residues of pesticides were surveyed in 132 samples of cow. The results showed that 0.76% of samples were contaminated with HCH (alpha isomer) and 10.60% with endosulfan (alpha and beta isomers), which are lower percentages compared to the current study (Ciscato et al., 2002). Research on poultry eggs in leishmaniasis endemic domiciliary areas, located in Rio de Janeiro, showed that the accumulation of DDT is alarming. Poultry eggs presented, on average, 1.980 ng g^{-1} of extractable lipids of ∑DDT (twice the maximum allowed by FAO), containing 82% of p,p′-DDE (Vieira et al., 2000).

Based on the results regarding the presence of contaminants in the north and southeast of Brazil reported by the studies mentioned, the concentrations found in milk are below the reported values. Additionally, in the south of the country, we can find data that are similar to the data obtained by this study.

In Europe, Japan, China, the United States, India, and Latin America, among other countries, the presence of organochlorine compounds in foods, human biological fluids, and environmental matrices is frequently reported (Miranda-Filho et al., 2007; Kang et al., 2008; Castilla-Pinedo et al., 2010; Vizcino and Grimalt, 2010; Bulut et al., 2011; Baek et al., 2011; Kaushik et al., 2011; Kampire et al., 2011; Wanga et al., 2011; Fromberg et al., 2011; Nag and Raikwar, 2011).

A study in India showed concentrations above the ones present in the milk from Mato Grosso do Sul. The average concentration of HCH was 162 ng g^{-1}, whereas ∑DDT was found in 114 samples in concentration of 172.4 ng g^{-1} (Nag and Raikwar, 2008). In Haryana (India), samples of bovine milk were collected and analyzed from 1992 to 1998 in rural areas from 14 different localities. The study showed that in this period there was a decrease of HCH (67.5%) and DDT (92.8%) concentrations. Even the lower values of these contaminants are above the concentrations obtained in the milk studied (Kaushik et al., 2011). Furthermore, in Turkey, a 2010 study measured concentrations of organochlorinates (OCPs) in bovine, buffalo and sheep milk. Eleven pesticides were identified in the bovine milk, and the average concentration of beta-HCH was 0.0913 μg mL^{-1}. The study showed that three OCPs were found to be higher than the maximum residue levels accepted by EU food codex (beta HCH, endrin and methoxychlor/91.32 ng mL^{-1}, 4.57 ng mL^{-1} and 24.99 ng mL^{-1} respectively) (Bulut et al., 2011). In the present study beta HCH and methoxychlor were not detected. Endrin concentration was 0.15 ng mL^{-1}.

In Iran, 54 samples of pasteurized bovine milk were investigated, and organochlorinated pesticides and polychlorinated biphenyl were found. The concentrations of HCH and DDT found were higher (31.89 and 21.65 ng g^{-1} of fat, respectively) compared to the ones verified in this study (2.34 and 16.72 ng g^{-1} of fat, respectively). However, Dieldrin exhibited a maximum concentration of 14.73 ng g^{-1} of fat in the milk from Mato Grosso do Sul (Brazil), and it was not identified in the study mentioned (Bayat et al., 2010). Besides that, in Cartagena, Colombia, the adult population's exposure to organochlorates was studied based on the ingestion of local pasteurized milk. Contamination by organochlorines was found in 100% of the analyzed samples ($n = 47$). The results indicated higher levels of contaminants compared to the ones found in Mato Grosso do Sul (Castilla-Pinedo et al., 2010).

Altogether, this study demonstrates the presence of organochlorine residues in bovine milk—in some cases, in quantities above the reference values. The study also highlights the need to monitor these contaminants, possibly with integrated approaches capable of supporting measures for environmental health surveillance in light of precautionary science.

The chlorinated pesticides found in the studied milk samples can indicate the use of these pesticides in agriculture, even though Brazilian legislation has not allowed the use of HCH since 1985 and the use of endosulfan has been limited. Regardless of the source, these compounds should not be in milk intended for human consumption because it can negatively affect health.

Therefore, it is necessary to continue monitoring organochlorine pesticide residues in milk, other animal products, and vegetables

produced in the region of the present study. This region has yet to be thoroughly characterized for pesticide contamination, and therefore, additional studies are required to examine this issue. Further studies will allow a general overview of these contaminants in the areas contributing to exposure risks from the standpoint of food safety. It will also be important to monitor trends of such contaminants in the environment after restrictions and prohibitions go into effect.

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