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PRESENCE OF INORGANIC CONTAMINANTS IN FARM-RAISED FISH AND WILD-CAUGHT FISH

PRESENÇA DE CONTAMINANTES INORGÂNICOS EM PESCADO DE CULTIVO E CAPTURA

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ABSTRACT

Commercial fishing and fish farms represent important sectors in the food industry. The global demand for these products had a significant increase in the last decades, due to the growth of the population, increase in income and in urbanization. To ensure a safe product to the population, the National Plan for Control of Residues and Poisoning (PNCRC) was developed, analyzing risks in products of both fishing and farming, aiming to ensure quality in food product throughout the production chain. In this way, the current document analysis aimed to verify, through reports from 2010 to 2016, the presence of inorganic poisons in fish from farming and commercial fishing. From those reports, the number of unsatisfactory samples in regards to poisons was extracted. This study reported that only fish from commercial fishing showed sample numbers with contamination from mercury, arsenium, plumbum and cadmium, with variations from 8,61% and 25,95%. These contaminated fish shouldn't be made available for human consumption. For this reason, the NPCRP is an important tool to manage the risks of poisoning, promoting chemical safety on food with animal origins produced in Brazil.

Keywords: Arsenic. Cadmium. Contaminants. Fish. Mercury. Plumbum.

RESUMO

A pesca extrativa e a criação de peixes representam importantes setores da produção alimentícia. A demanda mundial por esses produtos teve aumento significativo nas últimas décadas, fato que se deve ao crescimento populacional, aumento de renda e de urbanização. Para garantir um produto seguro à população, foi desenvolvido o Plano Nacional de Controle de Resíduos e Contaminantes (PNCRC), que realiza análises de riscos em pescados de cultivo e captura, visando à garantia de qualidade por meio da produção de alimentos ao longo de sua cadeia produtiva. Desse modo, a presente análise documental teve por objetivo verificar, nos relatórios de 2010 a 2016 do PNCRC, a presença de contaminantes inorgânicos em pescados de cultivo e captura. Foram retirados dos relatórios o número de amostras em situação insatisfatória quanto à presença desses contaminantes. Verificou-se, com este estudo, que apenas os pescados de captura apresentaram números amostrais contaminados com mercúrio, arsênio, chumbo e cádmio, que variaram entre 8,61% e 25,95%. Esses peixes contaminados com compostos inorgânicos não poderiam ser encaminhados para o consumo humano. Por este motivo, o PNCRC é uma ferramenta importante para gerenciar os riscos de contaminações, promovendo a segurança química dos alimentos de origem animal produzidos no Brasil.

Palavras-chave: Arsênio. Cádmio. Chumbo. Contaminantes. Mercúrio. Peixes.

INTRODUCTION

According to National Law No. 11.958 (BRASIL, 2009), fish meat is fish, crustaceans, molluscs, amphibians, turtles and fresh or salt water mammals. The world demand for these products has undergone a significant increase in recent decades: *per capita* consumption rose from 9.9 kg/year in the 1960s to 19.2 kg/year in 2012. This is mainly due to population growth, income increase and urbanization, besides the emergence of more efficient distribution channels, totaling an annual growth of 3.2% in the last 50 years (FAO, 2014a; FAO, 2014b).

The domestic market consumes about two-thirds of the production of several agribusiness products, besides being increasingly demanding regarding the food quality of the product and the environmental consequences related to its production (REGATTIERI *et al*., 2007; GALVÃO, 2011; CONTINI *et al*., 2012). In this sense, the product resulting from the national fishing activity (withdrawal of fish resources from the natural environment) and from aquaculture (cultivation of aquatic organisms, usually in a confined and controlled space) must keep its organoleptic and sanitary characteristics for human consumption.

However, in aquatic environments, highly toxic metals such as plumbum, cadmium, arsenic and mercury are present as inorganic contaminants, whose origins can be natural, geological or resulting from human activities, such as domestic and industrial sewage discharges (LOPES, 2009; BANDOWE *et al*., 2014). This accumulation of contaminants in the aquatic environment is a concerning, as fish are contaminated through ingestion and bioaccumulation and human beings, in a tertiary manner, have their health exposed to a series of diseases, causing risks to human health (SOUZA *et al*., 2013).

In order to inspect food of animal origin, including fish, Ministerial Ordinance No. 51 (BRASIL, 1986) instituted the National Plan for the Control of Waste and Contaminants (NPCWC), which was adapted by Ministerial Ordinance No. 527 (BRASIL, 1995) and amended by Normative Instruction No. 42 (BRASIL, 1999). NPCWC, in short, analyzes the presence of chemical substances potentially harmful to human health (MAURICIO *et al*., 2009).

Based on the above, the present work aimed to conducted a documentary analysis of the reports published by the NPCWC, describing the results obtained regarding the presence of inorganic contaminants in farm-raised and wild-caught fish that reach the table of Brazilian consumer.

MATERIAL AND METHODS

It was a documental analysis in which the reports of the National Plan for the Control of Waste and Contaminants – NPCWC/Animal, published by the Ministry of Agriculture, Cattle and Supplying (MACS), were evaluated. Reports for the years 2010, 2011, 2012, 2013, 2014, 2015 and 2016 were used, all available in full on the MACS website.

The number of samples of unsatisfactory farm-raised and wild-caught fish samples was collected from the reports, in other words, those that presented levels of inorganic contaminants (mercury - Hg, arsenic - As, cadmium - Cd, plumbum - Pb) above what was established by law (RDC No. 42 of August 2013), which provides for maximum limits of inorganic contaminants in food.

The results were presented descriptively, in a manner which the data obtained are presented in the form of tables, through absolute (n) and relative (%) numbers.

RESULTS AND DISCUSSION

Through the National Plan for the Control of Waste and Contaminants in products of animal origin/MACS, it was inspected the risk analysis in farm-raised and wild-caught fish, aiming to guarantee quality through the production of food throughout its production chain.

Extractive fishery and fish farming represent important sectors of the world's food production. Extractive fishery has been declining in recent years due to the reduction of natural stocks, while aquaculture has been showing steady growth (IBGE, 2011; LOPES *et al*., 2016). The high nutritional value of fish and the dissemination of studies that associate it with reducing diseases and improving health has been in recent years the reason for the increased interest in this food (BURGER, 2008; OLIVEIRA, 2013).

Table 1 - Distribution of farm-raised and wild-caught fish analyzed according to the presence or absence of inorganic contaminants (As, Cd, Pb, Hg).

Wild-caught Fish							
General Results/year	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Number of analyzed samples (n)	226	244	215	131	116	131	78
Percentage of compliant samples (%)	100	91.39	79.53	74.05	86.21	80.15	87.18
Number of non-compliant samples (n)	0	21	44	34	16	26	10
Percentage of non-compliant samples (%)	0	8.61	20.47	25.95	13.79	19.85	12.82
Farm-raised Fish							
General Results/year	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Number of analyzed samples (n)	114	146	62	67	65	74	61
Percentage of compliant samples (%)	100	100	100	100	100	100	100
Number of non-compliant samples (n)	0	0	0	0	0	0	0
Percentage of non-compliant samples (%)	0	0	0	0	0	0	0

Source: the authors.

The results of the program allow to verify whether commercialized in retail foods present levels of inorganic contaminants. Table 1 shows that inorganic residues can be found mainly in wild-caught fish, probably because they are more susceptible to changes in environmental contaminants, coming from natural, geological or human activities, such as domestic and industrial sewage discharges, medicinal products and/or waste associated with aquaculture, organic compounds and metals (SANTOS *et al*., 2006; OLIVEIRA, 2013; BANDOWE *et al*., 2014).

According to Andretto *et al*. (2014), wild-caught fish become more likely to be contaminated than farm-raised fish, where there is greater control of the habitat. Fish considered unfit for human consumption, due to its contamination, must be discarded and the area from which it was obtained, interdicted. The identification of the possible emitting source of inorganic contaminants allows the implementation of contamination control programs (SANTOS *et al*., 2006).

The percentage of non-compliance in wild-caught fish reached a maximum value of 25.95% in 2013. Basically, this result shows that in 2013, one in four samples were in non-compliance. In the years 2012 and 2013, the percentage of non-compliant samples was 11.86% and 17.34%, respectively, above what was found in relation to 2011. This index may be associated with a high concentration of metals in the wild-caught fish environment in this period, a fact that needs to be investigated.

Research conducted in the Cassiporé river basin, located in the northern portion of the State of Amapá, showed a concentration of heavy metals above the Maximum Permissible Concentrations (MPC), established by the Ministry of Health of Brazil, evidencing the contamination of the water environment in this basin. Consequently, high concentrations of Cd, Pb, Cr and Hg were found along the main watercourse of the Cassiporé river basin. Although the values presented in the study were lower (1.6% Cd, 0.68% Pb and 4.79% Hg) than those found in the same year (2012) in the ANVISA reports, the concentrations of heavy metals in the environment and fish muscle tissue indicate a high degree of contamination in the Cassiporé river basin and, therefore, a risk to human health (LIMA *et al*., 2015).

In southern Brazil, in Tramandaí, Rio Grande do Sul, the presence of heavy metals (As, Cd, Pb and Hg) was verified, and 33.3% of fish were found with As concentrations above the maximum allowed limit, while all samples of Cd, Pb and Hg had concentrations below the maximum allowed limit (PETERSEN; DAMIN, 2016). Filho *et al.* (2012) investigated the bioaccumulation in three fish species in Pontal da Barra, Laguna dos Patos, Pelotas, in 2011. The authors evaluated several compounds, including Cd and Pb, which obtained data between 3.14%-10.75% and 6.33%-13.75%, respectively. These results corroborate data taken from the NPCWC reports. The study relates the results with industrial and urban waste, as well as with agricultural activity. On the other hand, samples collected in Rio das Antas showed a high chromium concentration in 100% of the samples, which was associated with industrial activities (ANGHEBEN *et al*., 2019).

Assessing other regions of the country, it is possible to see that there is a cause for concern with regard to contamination in wild-caught fish. In the Amazon, results of studies point to mercury levels that call for concern in piscivorous fish (average of 669 ng/g), above the levels considered by the WHO as the maximum allowed limit for consumption (500 ng/g) (SOUZA; BARBOSA, 2000). In Pará, fish samples collected in the Rio Gelado, municipality of Parauapebas, were analyzed and it was found that all species (piranha, tucunaré, whitefish) presented Cd and Cr contents above the maximum value allowed by Brazilian legislation. The authors emphasize that both elements, Cd and Cr, are not part of the local geochemistry and may have anthropic origin, in other words, resulting from human action, since this river is subject to tailings from one of the largest mining companies in the world (BARROS *et al*., 2010).

The southeast region of Brazil, specifically the Rio Doce estuary, Espírito Santo, was impacted by the collapse of an iron mine tailings dam in 2015. Gabriel *et al*. (2020) described previously unreported bioaccumulation of metals and metalloids in edible fish in the region, nearly two years after a mine tailings disaster, whose observed increases in sediment metal concentrations were above 1000% for most elements studied (Cd, Cr, Pb and Zn). The authors found metal concentrations in liver and muscle tissue above Brazilian and international guidelines for Maximum Residue Limits in foods for As, Cd, Cr, Cu, Mn, Pb and Zn.

The Guanabara Bay, in Rio de Janeiro, still in the Southeast region of Brazil, is impacted by the release of sewage, oil and heavy metals, with Cr considered as one of the main industrial contaminants in the Bay. In the study by Kehrig *et al*. (2007), the Cr present in the muscle tissue of the two species of fish (croaker and mullet) was above the limit recommended for human consumption by Brazilian legislation

With regard to contamination in farm-raised fish, a study carried out in a fishery in the region of Umuarama, Paraná, quantified the levels of heavy metals in the gills, viscera and musculature of Nile tilapia, lambari, piau and catfish. The contaminants that presented values above the limits established by ANVISA were Cu (piau viscera) and zinc (Zn, viscera and gills, as well as in tilapia and lambari musculature), indicating that these fish would be unfit for human consumption (SOUZA *et al*., 2009).

The average percentage of contamination in the six years in which inorganic contaminants were found (from 2011 to 2016) was 16.91%. For each non-compliance found during the monitoring of the NPCWC, an inspection of the property is started, in order to diagnose the situation, identifying probable causes of the non-compliance and adopting corrective and preventive measures to minimize the risk of new occurrences. When tests confirm violation of allowable residue limits, the owner and responsible regulatory agencies are notified and the property is prohibited from commercializing the fish until further tests show negative results, these tests are performed every 90 days apart. It is important to emphasize that if the use of prohibited substances in the handling of animals is proven, the owner will be subject to Federal Police sanctions.

According to Souza and Barbosa (2000), mercury pollution in Brazil can be remedied with pollution control proposals: environmental education for the population, including fishermen and miners, action by society as a supervisor, adequacy of the mining work, creation of alluvial crashing, recovery of degraded areas and monitoring of environmental contamination.

Considering that fish production has been growing to meet market needs, together with the development of the creation of aquatic organisms (MORGANO *et al*., 2005), if there is no prevention and quality control of this type of food, it enhances the risk to human health. One solution is to implement a tracking system in the fish production chain, which could serve to control, monitor, prevent and better assess cases of poisoning, reducing dangers to consumer health (SOUZA *et al*., 2015).

Inorganic contaminants found in fish, such as mercury, arsenic, plumbum and cadmium have no function in the human body and their accumulation, due to consumption, can cause serious illnesses (RUPPENTHAL, 2013), which can represent different health risks. These risks can be immediate or can have harmful effects in the medium or long term, as their contamination is progressive and cumulative in the kidneys, liver and central nervous system (MACEDO, 2012; MORGANO, 2005).

The clinical symptoms of intoxication by inorganic compounds can be manifested as mild to lethal intoxication, with frequent vomiting, tremors, ataxia, paralysis, aphonia, blindness, inability to concentrate, loss of vision and hearing, coma and death being common (MORGANO, 2005).

The RDC 42 (BRASIL, 2013) is quite clear in stating that "the levels of inorganic contaminants in food should be as low as possible, preventing contamination of the food at the source, applying the most appropriate technology in production, handling, storage, processing and filling, in order to prevent a contaminated food from being sold or consumed". Further, "food products that do not meet the established maximum content shall not be used as food ingredients". Therefore, these wild-caught fish contaminated with inorganic compounds could not be sent for human consumption, as they are considered inappropriate for consumption.

Recognizing that the well-being and health of human beings are universal rights, there is a clear importance of monitoring and controlling these compounds in food. In farming fishing management controls are conducted to ensure quality fish, including care with feed and water, compared to extractive fishery, where there are no means for controls to be conducted. Possibly, for this reason, the result of the table did not find any non-conforming sample in relation to inorganic compounds.

CONCLUSION

With the increase in the production and consumption of fish, the National Plan for the Control of Waste and Contaminants – NPCWC is an important tool to manage the risks of contamination, promoting the chemical safety of foods of animal origin, produced in Brazil. The heavy metal indices found in fish may be associated with the lack of treatment of domestic and industrial sewage, medicinal products, electronics and metals improperly dumped in rivers, lakes and seas, which could be avoided through preventive and educational actions by part of the Brazilian population in the fight against environmental pollution.

The wild-caught fish presented high numbers of mercury, arsenic, plumbum and cadmium in relation to the farm-raised fish, where no non-compliance was found. It is necessary to continuously apply the program to obtain more data and use it as a form of control, identifying contamination and working preventively.

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