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Mercury and cyanide in Amazonian foods: Is this a risky diet?

Mercurio e cianeto em alimentos da Amazônia: Seria essa uma dieta de risco?

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ABSTRACT

Mercury and cyanide are present in two important types of food that make up the Amazonian table, and both are considered toxic to humans, which can cause various diseases and even lead to death. The aim of this study is to discuss the risks of human exposure to mercury and cyanide through food in the Amazon region. The present study is a narrative review developed with studies from the last 20 years (2003 to 2023) selected from the scientific databases Virtual Health Library, Pubmed and Science direct. The results of the selected studies confirm the presence of Hg in fish and cyanogenic residues in cassava flour. In addition, several studies have shown the high toxicity of both substances, which can lead to various negative alterations in systems that are fundamental to maintaining life, such as the CNS, hematology and heart. We conclude that a chronic diet based on contaminated fish and cassava flour poses a risk to the health of fragile and special populations, since they depend mainly on these foods. However, one cannot fail to mention the cultural and economic importance of fish and flour for this population. It therefore deserves to be carefully assessed.

Keywords: Mercury, Fish, Hydrocyanic acid, Amazon, Food.

1 INTRODUCTION

There are two food groups that are almost always available in the diet of Amazon residents: those derived from *Manihot esculenta crantz*, popularly known as cassava, and fish. However, these foods can contain harmful toxins, such as hydrocyanic acid (HCN) and mercury (Hg), respectively (IBGE, 2016, ABTONES *et al*., 2019).

The cassava root is used to produce table flour, which is widely consumed by the Amazonian population (SILVA *et al*., 2018). However, the plant has cellular components that naturally produce cyanogenic glycosides and are extremely toxic to humans, due to their deleterious effects on the CNS, hematology, kidneys, liver and thyroid (DOREA, 2004; CHISTE AND COHEN, 2006).

However, the consumption of flour and fish at the same time is common in the northern region of Brazil. However, just as flour can have significant levels of HCN, some species of fish from the Amazon have shown significant levels of mercury, and above 0.5µg/g, the limit recommended by the World Health Organization (WHO) (CASTRO *et al.*, 2016).

In this context, it can be seen that both substances are harmful to humans when exposed through food, and this needs to be discussed. This synergy needs to be better understood in order to understand the long-term damage to biological systems. This study therefore aims to discuss the risks of chronic exposure to mercury and cyanide through food in the Amazon region.

2 METHODOLOGY

This is a narrative literature review, descriptive in nature and with a qualitative approach, carried out in 2023. It was guided by the following question: Is exposure to mercury and cyanide through food a diet that risks the health of its consumers? To answer this question, a survey was carried out of scientific articles published in the last 20 years (2003 to 2023), available free of charge in the health science databases Virtual Health Library, Pubmed and Science direct.

The search words in the databases were mercury, hydrocyanic acid, Amazon, fish, *Manihot succulenta crantz* and Amazon, in English and Portuguese. All the words are registered on the Health Vocabulary Descriptors - DEC'S page. The search strategy used the Boolean operators *and* and *or*.

The inclusion criteria were articles in English and Portuguese that were available in full text. Articles that did not consider exposure to mercury and cyanide through food were considered ineligible.

The results of the research are addressed through a thorough analysis by at least two authors of the main findings of the selected studies in a descriptive way from a theoretical and contextual point of view, prioritizing a critical and reflective approach to the selected literature.

3 DEVELOPMENT

3.1 CASSAVA (CYANIDE)

In Brazil, cassava production is well distributed and the plant is grown all over the country. In the state of Pará, its importance is due to its high production, demanding a large number of workers and generating around 200,000 jobs in the state (GUSMÃO *et al.*, 2016). Cassava stands out in the group of temporary crops and agricultural production (FAPESPA, 2015).

In its cultivation, the presence of nitrogen in the soil can influence the concentration of cyanide in cassava. The content decreases linearly with the age of the plant and can vary between its parts. The range of levels of these glycosides is used to classify cassava plants as tame (low levels), wild (high levels) and intermediate (GAZOLA *et al.*, 2018).

3.2 MERCURY (Hg)

Several states in Brazil with large-scale mining activities in the Amazon region are contaminated by mercury (Hg). Firstly, the state of Amazonas (AM) with 0.02912 mg/g, followed by the state of Rondônia (RO) with 0.1525 mg/g, then the state of Pará (PA) with 0.01106 mg/g and finally Amapá (AP) with 0.0106 mg/g (GUIMARÃES; 2013). In these states, the most contaminated rivers are the Rio Negro with 0.205, followed by the Tapajós, 0.183, Madeira 0.86 and 0.5 and 0.6 Hg(mg/g) Xingu and Amazonas respectively (BASTOS, 2012. GUIMARÃES; 2013).

As a result, fish species such as *Charasidae sp.* (Lambari), *Pseudoplatystoma corruscans (*Pintado), *Hoplias malabaricus (*Trairá), *Pseudoplatystoma Linnaus (*Surubin), *Pellona Valenciennes (*Sarda), *Astronotus sp.* (Cará/Apaiari) have the highest concentrations of total Hg (AMARO *et al*.,2014, CASTRO *et al.*, 2016, MILHOMEM *et al.*, 2016).

While there has been a decrease in mercury in the environment compared to the 1980s, a period known as the "gold rush", mercury can still remain in nature for a long time, posing risks to human health (MALAQUIAS, 2015).

3.3 CYANIDE TOXICOKINETICS AND TOXICODYNAMICS

The cassava root produces table flour, which is widely consumed by the Amazonian population (SILVA *et al.*, 2018). However, the plant has cellular components that naturally produce cyanogenic glycosides. The compound is released by hydrolysis during rupture of the plant cell wall, which, in the presence of linamarin and linamarase present in its composition,

releases hydrocyanic acid (HCN) as a product (OLIVEIRA *et al*., 2014; SHIBAMOTO AND BJELDANE, 2014).

Cyanide is rapidly absorbed by the body regardless of the route of introduction (respiratory mucosa, gastrointestinal tract, skin and eyes if contact is continuous). This is due to its low molecular weight, solubility in water and lipids and its toxic effects can occur within a few minutes. The ingestion of cyanide salts favors the release of hydrocyanic acid by the action of hydrochloric acid present in the stomach, absorbed in the form of cyanide ions (AZEVEDO *et al.*, 2015).

Although hydrocyanic acid is considered a substance of ecological function for cassava, it is extremely toxic to humans due to its deleterious effects on the Central Nervous System, hematology, kidneys, liver and thyroid (DOREA, 2004; CHISTE AND COHEN, 2006; SHIBAMOTO AND BJELDANES, 2014, ABTONES *et al*., 2019).

The studies by Almeida (2015) and Baia and Melo (2017), carried out on flour sold at a street market in Belém and Bragança in the state of Pará, respectively, showed cyanide results above 10mg/Kg of cassava, which is considered an acceptable limit for safe consumption according to ANVISA.

In cases of suspected and confirmed poisoning, in addition to the administration of oxygen and measures aimed at maintaining the cardiovascular system, drug therapy must be carried out, the essential measure to reduce the patient's chances of death.

Among the drugs used, hydroxocobalamin is considered a very effective antidote. It replaces its hydroxyl group with free cyanide in the plasma, forming cyanocobalamin, which is excreted in the urine, rapidly improving heart rate and systolic blood pressure and reducing acidity (CONITEC, 2015).

3.4 TOXICOKINETICS AND TOXICODYNAMICS OF Hg

The rate at which Hg is absorbed depends on the route of exposure and the chemical form of the metal. When inhaled, metallic mercury is absorbed in an average of 80% (FILHO, 2009) and in the form of methylmercury, 95%, through the consumption of contaminated food. The methylmercury present in fish is metabolized in the liver. However, this conversion is quite slow. In addition, the fact that the human body has no other way of eliminating the metal contributes to methylmercury accumulating continuously over time, even if exposure is not so continuous (FILHO, 2012).

Neurological alterations have been reported in populations exposed to mercury in the Amazon (SILVEIRA, *et al.*, 2004; KHOURY *et al.*, 2013, MORENO DOMINGUEZ, *et al.*, 2017). Methylmercury in the CNS can contribute to an increase in glutamate and inhibition of the uptake of this neurotransmitter in the synaptic cleft of astrocytes. This condition in an adult can lead to impairment of the hippocampus and cerebellum, resulting in neuronal loss, directly affecting vision, hearing, the somatic sensory and motor systems (ASCHNER *et al*., 2007).

It is important to consider exposure to Hg through food in the body, especially by population groups in the Amazon at easy risk of exposure. Studies have shown changes in various oxidizing markers such as methemoglobin levels and plasma membrane lipoperoxidation, which are widely used as markers of oxidation of biological organic molecules (SILVA, 2011; KHOURY *et al*., 2013; SILVA *et al.*, 2016; RIVADENEYRA-DOMINGUEZ *et al.*, 2017).

4 FINAL CONSIDERATIONS

Considering the findings, we believe that exposure to mercury and cyanide through food can be harmful to the health of certain population groups, especially those who focus on fish and cassava flour as their main sources of protein and carbohydrates, respectively.

Food is responsible for more than 30% of diseases today. This is due to chronic exposure, characterized by small doses, but no less important on a toxicological level. Therefore, fish and cassava flour need to be monitored for the presence of chemical substances that are toxic to humans and affect various biological systems.

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