



# LETTER TO THE EDITOR

## Chlorpyrifos should be banned in agriculture and livestock production in Colombia

*El clorpirifos debería prohibirse en la producción agrícola y ganadera en Colombia*

*O clorpirifós deveria ser proibido na produção agrícola e pecuária na Colômbia*

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### Abstract

Chlorpyrifos (CPF) is a pesticide widely used in Colombia's agriculture, including crops, farm animals and pets, despite it has been banned for use in the European Union and the United States. Studies demonstrate that even low blood levels of CPF -which do not inhibit blood acetylcholinesterase- can lead to child developmental and neurological disorders such as smaller head circumference and brain alterations, and psychomotor and cognitive deficits related to learning ability, attention and memory. In adults, CPF is an endocrine disruptor and breast carcinogen. High direct and indirect economic costs have been associated with CPF exposure. Not only farmers and their families -who have the highest exposures- but the general population consuming crops sprayed with CPF are also at risk. For these reasons CPF was recently banned by the European Union (2020) and the USA (2021). Pesticide regulation policies vary greatly depending on which and how scientific studies are used to assess health risks. Pesticide evaluations funded by the chemical industry should be rectified to avoid conflicts of interest. Furthermore, political alignment with the interests of the industry should not take precedence over independent scientific evidence. It is discouraging, to say the least, that until stricter health laws are passed in Colombia, CPFs and related pesticides will continue to be imported from those countries that have already banned them. Colombian scientists should raise their voice to challenge blind acceptance of profits over unintended consequences, and efforts to prevent pesticide's abuse should be encouraged.

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**Keywords:** *agriculture; chlorpyrifos; cognitive disorders; Colombia; health risks; endocrine disruptors; carcinogen; insecticides; import ban; import policies; food residues; livestock production; organophosphates; pesticides; prenatal exposure.*

## Resumen

El clorpirifos (CPF) es un pesticida ampliamente utilizado en la agricultura de Colombia, incluidos cultivos, animales de granja y mascotas, a pesar de haber sido prohibido en la Unión Europea y Estados Unidos. Los estudios han demostrado que incluso niveles bajos de CPF en sangre -que no inhiben la acetilcolinesterasa sanguínea- pueden provocar trastornos neurológicos y del desarrollo infantil, como menor circunferencia de la cabeza y alteraciones cerebrales, y déficits psicomotores y cognitivos relacionados con la capacidad de aprendizaje, la atención y la memoria. En adultos, el CPF es un disruptor endocrino y causante de cáncer de mama. Altos costos económicos directos e indirectos se han asociado con la exposición al CPF. No solo los trabajadores agrícolas y sus familias, que están más expuestos, sino también la población en general que consume cultivos rociados con CPF también están en riesgo. Por estas razones el CPF fue prohibido recientemente por la Unión Europea (2020) y los EE. UU. (2021). Las políticas de regulación de plaguicidas varían mucho según los estudios científicos escogidos para evaluar los riesgos para la salud. Las evaluaciones de plaguicidas financiadas por la industria química deben rectificarse para evitar conflictos de interés. Además, ante la evidencia científica independiente no debería prevalecer la alineación política con los intereses de dicha industria. Es desalentador, por decir lo menos, que hasta que se aprueben leyes de salud más estrictas en Colombia se seguirán importando CPF y pesticidas relacionados desde aquellos países que ya los han prohibido. Los científicos colombianos deben alzar la voz para desafiar la aceptación ciega de ganancias por encima de las consecuencias no deseadas en salud pública, y se deben alentar los esfuerzos para prevenir el abuso de pesticidas.

**Palabras clave:** *agricultura; Colombia; clorpirifos; disruptor endocrino; carcinógeno; contaminación alimentaria; exposición prenatal; insecticidas; organofosforados; pesticidas; políticas de importación; producción ganadera; prohibición de importación; riesgos de salud; trastornos cognitivos.*

## Resumo

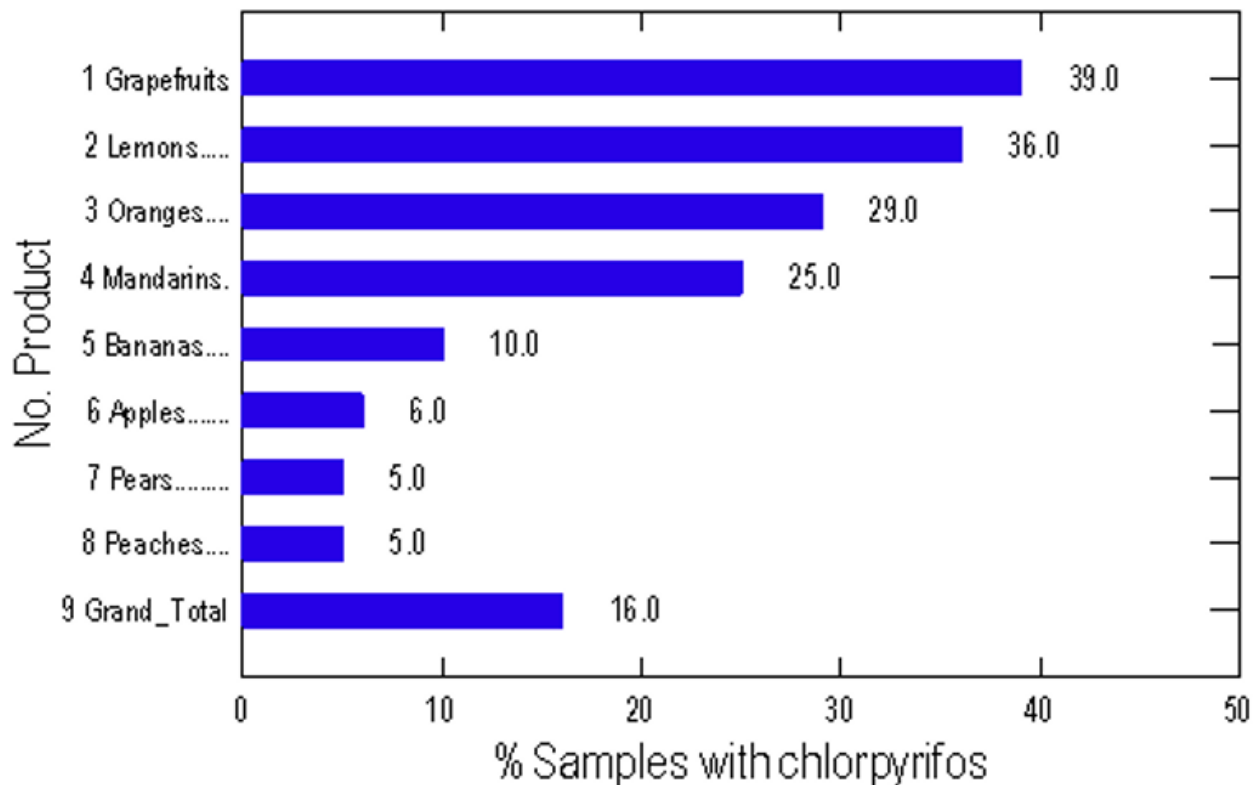
Clorpirifós (CPF) é um pesticida registrado amplamente utilizado na agricultura colombiana, incluindo lavouras, animais de fazenda e animais de estimação, apesar de ter sido proibido na União Europeia e nos Estados Unidos. Estudos têm demonstrado que mesmo níveis baixos de CPF no sangue -que não inibem a acetilcolinesterase sanguínea- podem levar a distúrbios neurológicos e de desenvolvimento em crianças, como menor perímetro cefálico e alterações cerebrais, além de déficits psicomotores e cognitivos relacionados à capacidade de aprendizagem, atenção e memória. Em adultos, o CPF é um desregulador endócrino e cancerígeno da mama. Altos custos econômicos diretos (devido ao tratamento) e indiretos (devido à perda de produtividade) têm sido associados à exposição ao CPF. Não apenas os trabalhadores agrícolas e suas famílias, que têm as maiores exposições, mas a população em geral que consome culturas pulverizadas com CPF também estão em risco. Por essas razões, o CPF foi recentemente proibido pela União Europeia (2020) e pelos EUA (2021). As políticas de regulamentação de pesticidas variam muito, dependendo de quais (e como) os estudos científicos são usados para avaliar os riscos à saúde. As avaliações de pesticidas financiadas pela indústria química devem ser retificadas para evitar conflitos de interesse. Além disso, o alinhamento político com os interesses da indústria não deve ter precedência sobre as evidências científicas independentes. É desanimador - para dizer o mínimo - que até que leis de saúde mais rígidas sejam aprovadas na Colômbia, o CPF e tóxicos relacionados continuarão a ser importados dos países que já os proibiram.

**Palavras-chave:** *agricultura; Colômbia; contaminação alimentar; clorpirifos; exposição pré-natal; distúrbios cognitivos; inseticidas; organofosforados; pesticidas; políticas de importação; produção pecuária; proibição de importação; resíduos tóxicos; riscos de saúde; toxinas ambientais.*

Chlorpyrifos (CPF) is the main pesticide used in Colombia for agriculture and livestock. According to ICA (2021), pesticides registered in Colombia include 28 CPF-based products for use in agriculture, excluding livestock (*e.g.*, Attamix SB). During 2019, a total of 2,692 tons of CPF were commercialized by Colombian importers (ICA, 2019). Most CPF products are ICA class II (moderately) or III (slightly) toxic based on acute toxicity (LD50), but these classifications do not apply to high chronic exposures (manufacturing and use) and chronic ingestion of low concentrations in food. Residue concentrations in agricultural products and considered acceptable before are unsafe now, and CPFs have been recently banned by the European Union (EFSA, 2019) and the United States (USEPA, 2021; Federal Register, 2021). In 2019, before the ban of CPF, the European non-governmental organization “Health and Environmental Alliance” (HEAL) published a summary report showing the percentage of fruits and vegetable with CPF residues in European

Union markets (Figure 1) (Heal, 2019). Out of 165 pesticides analyzed, CPF was among the five most detected and the one most frequently exceeding tolerance levels.

Modeling CPF toxicity to human health is a classic example of how the characterization of pesticide exposure can affect regulations. Until 2016, the USEPA used acetylcholinesterase inhibition (AChE), considered the most sensitive biological effect of CPF, to establish that health risks of agricultural products with “tolerable” levels of CPF were low (USEPA, 2016). The rationale was that if acetylcholinesterase was not inhibited, a person was protected from neurotoxicity. However, using new data from unreported findings of industry-funded studies and epidemiological studies, the USEPA (2016) showed that CPF concentrations in umbilical blood lower than AChE inhibition predicted childhood developmental and neurological disorders.



**Figure 1.** Chlorpyrifos residues in fruits sold in the EU market with the highest frequency of detection.

An early study found a correlation between CPF concentration in maternal and newborn blood with low weight and shorter body length (Whyatt *et al.*, 2005). Children exposed to CPF *in utero* had lower IQs; psychomotor disorders; cognitive deficits related to learning ability, attention, and working memory; and brain structural alterations visible by Magnetic Resonance Imaging (MRI) (Rauh *et al.*, 2006). The probabilities of a lower Mental Development Index and Psychomotor Development Index were 2.4 and 5 times higher in children with elevated CPF exposures, respectively. At 7 years of age, children's IQs and working memories decreased by 1.4 and 2.8% for each standard deviation (4.6 pg/g) increase in CPF level (Rauh *et al.*, 2011). When the same children were 6-11 years old, prenatal exposure and brain structure alterations (by MRI) were associated with cognitive and behavioral problems (Rauh *et al.*, 2012). Specifically, children with higher prenatal exposure to CPF had significantly reduced frontal and parietal cortexes. Another study in Costa Rica showed that women (n=387 mother-infant pairs) exposed and excreting CPF metabolites in urine during the third trimester of pregnancy gave birth to children with smaller head circumference in both sexes [-0.66 cm (95% CI: -1.29; -0.04) per log<sub>10</sub> unit increase] (Van Wendel de Joode *et al.*, 2014). In a cohort of 140 Costa Rican children aged 6-9, higher urinary CPF concentrations were associated with poorer visual motor coordination, increased prevalence of parent-reported cognitive problems, decreased ability to discriminate colors, and poorer working memory in boys (van Wendel de Joode *et al.*, 2016b). Analogous neurological disorders to those found in children were later reproduced in rats at exact doses lower than inhibited AChE (Berg *et al.*, 2020; Russell *et al.*, 2017).

The CPF is one of many organophosphate and carbamate pesticides to which agricultural workers and inhabitants in Colombia are exposed. After starting work in floriculture, a cohort of 2,951 men and 5,916 women in the Bogotá region were occupationally exposed to 127 different types of pesticides. Symptoms included mental confusion (3.3%) and tremors

(2.2%). The prevalence rates of abortion, prematurity, and congenital malformations increased after starting work (Restrepo *et al.*, 1990). In a study of exposure to 1-11 classes of pesticides (but not CPF), all 50 floriculture workers in Cundinamarca, Colombia, had low AChE activity, between 0.056 pH/h and 0.445 pH/h in 27 men, and 0.052 pH/h to 0.264 pH/h in 23 women (Amaya *et al.* 2008). The AChE tests of 23 workers (20-40 years old) at a banana plantation in Urabá (2008-2009) identified subnormal activity in five people, and other three were at the limit level (Aguirre-Buitrago *et al.*, 2014). Of 204 occupationally exposed workers in four municipalities in Putumayo, 36 (17.6%) had inhibited AChE activity (Varona *et al.*, 2007).

Direct (due to treatment) and indirect (due to loss of productivity) economic costs are associated with CPF exposure. A European Union study determined that 13.0 million IQ points are lost annually, and 59,300 new people are affected by intellectual disability (autism and attention deficit disorders), accounting for 146 billion euros in social costs (Bellanger *et al.*, 2015). The CPF and other organophosphate exposures in the USA created estimated annual losses of billions of dollars in terms of IQ losses and brain development deficits (Attina *et al.*, 2016). Consequently, all use of CPF was banned by the European Union (2020) and USEPA (2021).

In addition to the effects in children, CPF is an endocrine disruptor and breast carcinogen. Wives of pesticide applicators (farmers), who used CPF in their homes had a significantly increased risk of developing breast cancer (hazard ratios=1.4; 95% CI:1.0-2.0); the risk was most pronounced for women diagnosed with premenopausal breast cancer (Engel *et al.*, 2017). Rats fed low doses of CPF for several weeks up to three months had morphological abnormalities in reproductive organs, including changes in mammary glands that were predictive of developing malignant mammary tumors (Nishi and Singh-Hundal, 2013; Ventura *et al.*, 2016). The effect occurs by inducing breast

cancer cells through the estrogen receptor Alpha (ER $\alpha$ ) on the mammary gland (Ventura *et al.*, 2016). The studies concluded that agricultural workers and their families have the highest exposures, but consumers eating fruits, nuts or other crops sprayed with CPF are also at risk.

CPF shows how pesticide regulation policy can vary greatly depending on which (and how) scientific studies are used to assess health risks. Several aspects of pesticide evaluation should be rectified: (1) All industry-financed studies should be commissioned by regulatory authorities to avoid conflicts of interest. The CPF studies funded by a manufacturer and submitted to the USEPA to renew registrations omitted critical data on toxic effects at doses below those in the application (Sheppard *et al.*, 2020). (2) Laboratories carrying out safety studies should demonstrate the ability to satisfactorily identify all possible adverse effects (*i.e.*, neurodevelopmental disorders for CPF) and the absence of conflicts of interest related with manufacturing, supplying, or applying the pesticide. (3) Regulatory scientists should have access to all documentation known to the company, including confidential data. (4) Epidemiological studies by researchers unaffiliated with the industry must be included in the risk assessment and pesticide authorization processes. (5) Political alignment with industry interests must not be allowed by law to override scientific evaluation processes and decisions, as occurred when the Trump administration (USA) prevented EPA from implementing a ban on CPF in 2017 (USEPA, 2017).

It is discouraging -to say the least- that until stricter environmental protection and public health laws are passed and implemented by Colombia, CPF and related chemicals will continue to be imported from countries that have already banned them (Dowler, 2020). Colombian scientists should raise their voice to challenge blind acceptance of profits over unintended consequences, and efforts to prevent pesticide's abuse should be encouraged.

## Declarations

### *Conflicts of interest*

The authors declare they have no conflicts of interest with regard to the work presented in this report.

### *Author contributions*

D.V: Conceptualization and writing of the manuscript. D.J.S: Critical review and editing.

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