Clima-LoCa

Fostering low-cadmium and climate-relevant innovations to enhance the resilience and inclusiveness of the growing cocoa sectors in Colombia, Ecuador and Peru.

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Briefing Note No. 5

Nickel: The new EU food safety regulation and what it means for the cacao and chocolate sector

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Key messages

- Nickel levels in chocolate and 14 other food groups will be regulated for the EU market from 1 July 2025 due to potential health risks.
- Nickel is a metallic element that is found in Earth's mantle, that comes to the crust along tectonic plate boundaries and may enter the food chain due to natural and anthropogenic processes.
- Nickel is an essential nutrient for plants and used in seed germination, so nuts, seeds, or beans (including cocoa) will always contain some nickel.
- Data from 359 chocolate bars and nearly 3000 trees from across the world suggest that the new maximum regulated limits can mostly be met.
- Chocolate made from beans with higher level of nickel comes from specific areas and appears related to their geological origin.
- Reducing nickel uptake by cacao is unlikely to be easy, but liming can be helpful if the soils are high in nickel and acidic. Applying silicates high in nickel should be avoided.
- For single-origin or bean-to-bar chocolate, it will be important to map nickel at a farm level to understand whether the mixing of beans or new recipes will be effective for compliance.

Farmers, practitioners, policymakers, industry officials, and other relevant actors in the cocoa value chain need to know about the EU regulation on nickel levels in chocolate. The objective of this set of Clima-LoCa Briefing Notes is to address common questions regarding food safety regulations for cacao in a science-backed manner to inform the value chain.

June 2025

Summary

On July 1 2025, the European Commission regulation 2024/1987 that sets limits of nickel in 15 food groups comes into force. Chocolate is one of the listed foods and the limits are: 2.5 mg nickel/kg for milk chocolate with less than 30% cocoa solids; 7 mg nickel/kg for milk chocolate with more than 30% cocoa solids, and dark chocolate (defined as having more than 35% cocoa solids); and 15 mg nickel/kg for cocoa powder and powdered chocolate on sale to the end consumer. These limits are placed on products on sale to the end consumer only. Any products made prior to 1 July 2025 can be sold regardless of the nickel level. All products that comply with these limits are equally safe for the consumer and should not be ranked against each other.

Nickel (Ni) is an essential micronutrient for plants and is a fundamental part of seed development. Seeds, nuts, beans and chocolate, as well as mushrooms and seaweed have the highest levels of nickel of the foods we eat. Nickel is naturally found in the soil and is very useful in our modern lives; used widely in batteries, stainless steel, electronics and coins. Mining and industry have led to air and soil pollution in some areas.

Some nickel compounds have been classified as carcinogens when they are inhaled and represent an occupational hazard for people working with it. While we appear to need a small amount of nickel in our diet, there is no evidence that nickel is carcinogenic when consumed. The main health concern about nickel comes from a study in rodents that suggests a relation between nickel consumption and increased loss of recently fertilised embryos. It is thought that the same effect may occur in humans. There is also concern of neurological effects but to date little data support this. Additionally, about 15% of the population in Europe are sensitised to nickel and suffer a severe skin reaction through dietary exposure or wearing of jewellery containing nickel. They are advised to eat a low-nickel diet.

Because of these health concerns, the EU has set a daily tolerable intake of 13 µg nickel per kg body weight per day, and a maximum of 4.3 µg for persons sensitised to nickel. These are acknowledged to be very conservative limits. Dietary analyses in Europe indicate that the average adult diet does not exceed this and the most vulnerable group (reproductive age females) are not being exposed excessively. A proportion of children´s diets appear to be higher than the limit. However, most of the diets examined exceed the level recommended for nickel-sensitised people.

Nickel is found in cocoa nibs because it is present in cocoa mass (non-fat), but not in cocoa butter or sugar. The nickel levels in a chocolate bar will thus be linked to the % of non-fat cocoa solids present. Nickel may also be a process contaminant in chocolate which contains manufactured hydrogenated fat.

The nickel levels in seven published studies and 359 chocolates on sale in Europe and the USA show an average of 3.6 mg/kg and that the limit of 7 mg/kg is exceeded by only 4%. A more detailed study from nearly 3000 trees from Colombia, Ecuador and Peru suggest an average 3.85 mg/kg and that 13% may not meet the limit. This is higher because the data comes from individual trees which are more variable.

In general, the cacao producing regions of the world appear to have similar mean values of nickel, but there are some hotspots. It appears that there is a relation with the presence of ultramafic soils which are found where the tectonic plates collide, causing the earth´s mantle to be exposed. Further data is needed to understand the relation between ultramafic soils and nickel uptake by cacao.

Reducing nickel uptake by cacao at a farm level is unlikely to be easy. Liming to raise the soil pH may be effective in soils that are high in nickel and acidic, but further research is needed. Application of silicates should also be avoided due to their high nickel content. For single-origin or bean-to-bar chocolate, it will be important to map nickel at a farm level to understand whether the mixing of beans or new recipes will be effective for compliance.

Q1 What is the new EU legislation 2024/1987 for nickel in foodstuffs?

The EU has set maximum levels of nickel (Ni) for 15 groups of food based on an average European diet using the tolerable daily limit of 13 µg/kg body weight per day. The regulation came into force on 1 July 2025, with an additional group (cereals) being added one year later. Any product legally entering the market prior to 1 July will be exempt from this regulation [1].

Q2 Where does nickel come from?

Nickel is a natural component of soils: Plants actively absorb nickel from the soil. While there is some nickel in all soils, the earth´s mantle is made of ultramafic rocks which have particularly high levels of nickel. When tectonic plates collide or volcanoes erupt, the mantle is pushed up to the surface of the earth and so the distribution of ultramafic rocks on the earth´s surface is related to tectonic plate boundaries. This means that there are areas in the world with higher-than-average concentrations of nickel in the soil. Given the increasing importance of nickel to humans, these areas are also where world´s largest nickel mines are found. For example, Indonesia (Maluku and Sulawesi), the Philippines, Madagascar, Colombia and Russia. For biologists these areas are also fascinating because they have unique plant flora that have evolved to survive in these condition [2].

Soils may also be polluted by human activities: Nickel is used to make coins, in electroplating, electronics, pigments and in ceramics. It is also a component of stainless steel and used as an alloy in renewable energy infrastructure, and nickel-rich batteries are used in electric vehicles. Mining, extraction and industry can result in localised soil contamination and air pollution, higher than most naturally occurring levels [3,4].

Nickel is an essential micronutrient for plants: It is key for seed germination, plant growth and development. It is present in the enzyme urease that is essential for nitrogen metabolism [5]. Seeds of many species (including legumes) are rich in this enzyme because they contain the protein arginine as a source of nitrogen which is released by urease. Legumes also use urease to transport nitrogen, and for inter-cell communication. It is also an important component of nitrogen release by soil microorganisms [6]. The level of nickel in the plant is however tightly regulated, and in high concentrations it causes significant physiological problems [7].

Q3 How does nickel end up in our diet?

As plants need nickel for seed germination, they will always have some in their tissues and analyses show that seeds and nuts (e.g. cashew) beans (e.g. soy), cocoa, chocolate, as well as seaweed and wild mushrooms contain the highest concentrations of nickel of the foods we eat [8]. While black tea, herbs and spices, and nutritional supplements also contain high levels, they are consumed in minute quantities. Another source of nickel could be from poor-quality stainless-steel equipment during food preparation, especially under acidic conditions, or other technical processes; however this does not appear to result in a large and consistent increase in nickel in food [4,9].


Cacao of Excellence

Q4 Why is nickel a problem for human health?

We can be exposed to nickel in two ways: through our diet and through inhalation. While nickel is not considered essential to human health, it appears that we need a small amount, and this is always achieved through our diet [10], ingested as a bivalent ion in complex organic compounds. When consumed in higher amounts, it may have both chronic and acute effects to health. However, to date these impacts have not been studied systematically in humans, so many of the effects of nickel are inferred from experiments on other organisms [8].

- **Chronic oral exposure:** Nickel does not accumulate in vertebrate tissue or organs, and has a half-life of about 28 hours, being washed out in the urine, so it is not classified as a carcinogen when ingested. There are no reliable data on neurological effects, although this is thought to be a concern. However, experiments feeding mice nickel showed an increased loss of recently fertilized embryos, and it is postulated that it could cause a similar effect in humans [8].
- **Acute oral exposure:** It is estimated that around 15% of the population in Europe, Asia and the USA are sensitized to nickel and can experience a flare up of eczema (systemic contact dermatitis) when they eat high-nickel foods or wear jewellery containing nickel. For these people, diets focussing on low nickel food are recommended to avoid stimulating this reaction [11].

In contrast, the inhalation of nickel sulphides, sulphates and oxides is considered an occupational risk for those working in nickel mining, smelting, and refining and can lead to significant health issues, including cancer [10]. Nickel compounds are thus classified under the European Union Classification, Labelling and Packaging (CLP) as potentially carcinogenic to humans, while the International Agency for Research on Cancer (IARC) classifies nickel as a Group 1 carcinogen, but only when it is inhaled [12].


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Q5 How were the limits for dietary exposure to nickel determined?

An updated tolerable daily limit (TDI) of 13 µg Ni/kg body weight per day was established from dose-effect modelling. This means that a person weighing 70 kg can consume 0.91 mg of nickel per day without worry (1 µg is 0.001 mg). Additionally, 4.3 µg Ni/kg bodyweight was calculated as the level that gives the lowest observed adverse effect in sensitised people [8].

The expert committee behind the EFSA report states that this is a very conservative limit and mentions the need for more and higher quality information to improve understanding of the risks of dietary exposure to nickel. For example, it is unclear how much of the nickel we eat is bioavailable and it may be less than 2.5%. Additionally, the TDI for nickel-sensitized people is based on a study that provided nickel in water to fasting individuals which makes its effect much more potent. And finally, the variability of response to nickel in experiments is so large that an uncertainty factor of 100 was applied to the original TDI estimate to take this into account.

Q6 Are Europeans at risk of exceeding these limits in their diet?

More than 47,000 dietary analyses from the EU that quantify nickel concentrations were used to determine the risk of exceeding these limits in an average diet [8]. The analyses showed that the TDI was not exceeded at the 95th percentile for adults and adolescents, but it was for toddlers (1-<3 years), less so for children (3-<10 years) and occasionally for infants. Interestingly, the most important dietary contribution of nickel for toddlers came from wheat (bread and other flour-based products), not because they have high nickel but because of the high consumption. A second study carried in Germany indicated similar trends, but found that fewer than 5% of children´s diets (0.5–5 years) exceed the TDI [9].

Potentially the most vulnerable group is women of reproductive age, and there appears no evidence of risk from dietary exposure for this group [8,9]. The EU regulation however states that the TDI has been set to protect younger age groups from other potential effects of nickel, due to a dearth of information [1].

Due to a lack of reliable data for understanding of acute exposure effects (for nickel-sensitized people), an analysis was carried out using the Margin of Exposure (MOE) which is the ratio of the level at which no effect occurs and the average exposure in the environment. An MOE of 30 or more is considered to cause no health concern for nickel-sensitized people. The dietary analysis mentioned above suggests an MOE of 0.3-2.3 [8].

Q7 What are the limits for nickel in cocoa powder and chocolate?

The EU regulation (EU 2024/1987) imposes three different limits of nickel in cocoa and chocolate products depending on the percentaje of cocoa solids. These limits are set for products available for the final consumer, and not for raw (e.g. cacao beans) or intermediary products (pasta, cocoa powder as an ingredient in chocolate or derivatives) **(Figure 1)**.

The EU regulation provides a maximum limit for nickel in chocolate to protect us from any possible impact of nickel. It is not made to rank chocolates but is a threshold that the product either passes or fails. Any analysis claiming that a chocolate with 1 mg/kg nickel is healthier than one with 6 mg/kg is not interpreting the regulation correctly. Both these chocolates are equally valid and will not incur health problems.

Category	mg/kg
Milk chocolate with <30% total dry cocoa solids*	2.5
Milk chocolate with ≥30% total dry cocoa solids, and chocolate**	7
Cocoa powder, fat-reduced powder, on the market for the final consumer as an ingredient in sweetened chocolate and powdered chocolate for sale to the end consumer	15

** The EU defines chocolate as that which contains >35% total dry cocoa solids.

* Total dry cocoa solids is the sum of fat and no-fat solids found in the cocoa mass

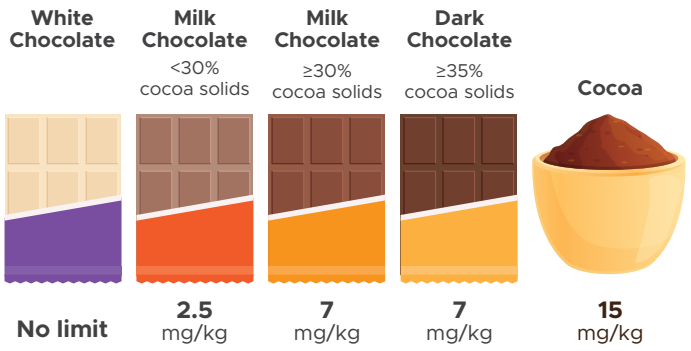

Figure 1: Maximum limits of nickel in different chocolate and derivatives as specified in the regulation EU 2024/1987.

Q8 Should the cocoa supply chain be concerned about nickel levels?

Six studies on chocolates on the market in Europe and one in the USA measured nickel in a total of 359 chocolate bars, all with more than 30% dry cocoa solids. The pooled average was 3.6 ± 1.94 mg/kg, with only 4% of the bars exceeding the 7 mg/kg limit [13–19] (Figure 2). There are only 6 commercial cocoa powders analysed to date from two studies, and the results indicate a pooled average of 13.0 ± 2.89 mg/kg. The limit is 15 mg/kg [14,15].

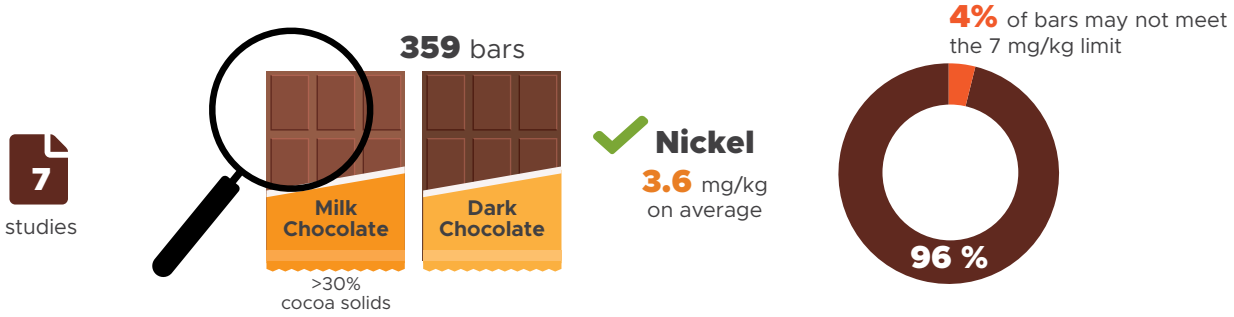

Figure 2: Nickel levels from 359 chocolate bars analysed in seven published studies (See text for references).

Q9 Are there regional differences in nickel?

A global survey: Combining the data from three published studies that look regional differences in heavy metal concentrations we find that while mean values from the cacao producing regions all comply with the 7 mg/kg limit, chocolate from Central America and the Caribbean has slightly higher levels, while there is a greater range in the sampled bars from Asia (Figure 3). This pattern points to the importance of Caribbean plate tectonics causing ultramafic rocks formed from the earth´s mantle to be pushed to the surface. The high variability of nickel levels in chocolate from Asian cacao suggests that there are areas with complex geogenic histories that may have high nickel content (e.g. Sulawesi) [2]. Data pooled from sources [16,17,19].

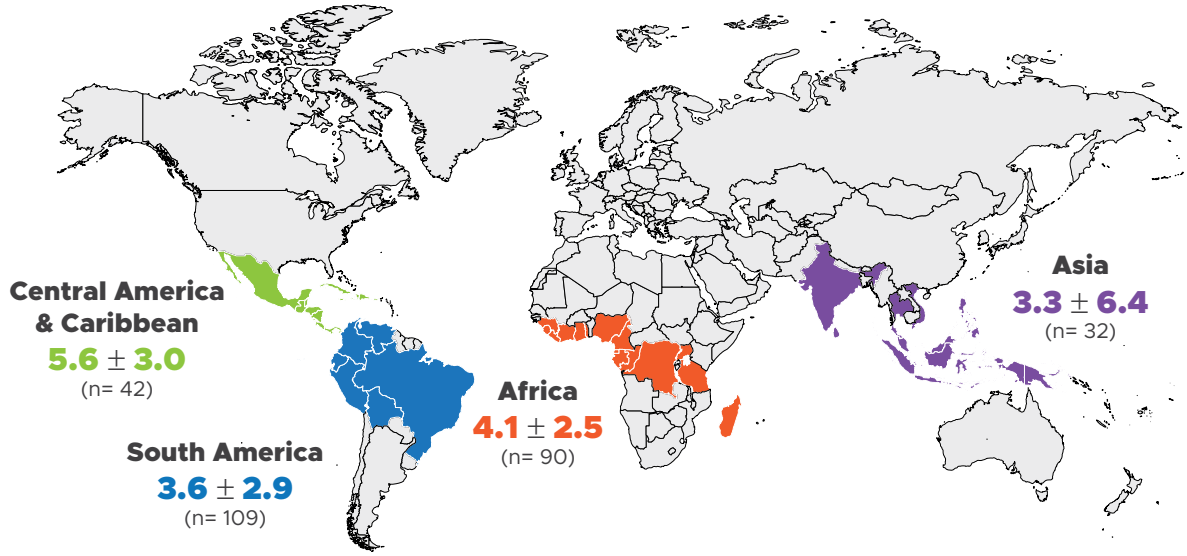

Figure 3: Average nickel level (mg/kg) in chocolate bars produced in the four major cacao-producing regions (Central America, South America, Africa and Asia-Pacific). Data comes from three published studies (See text for references).

South America: Peru, Ecuador and Colombia are important producers of cacao in South America, with both Peru and Ecuador focused on its exportation. Europe has always been an important market, although in the past years export to the Asian markets is increasing [20]. Country-wide analyses of nickel levels in 70% chocolate made by scaling data from beans collected from 2778 individual cacao trees, suggests a regional average (and standard deviation) of 3.85 ± 2.91 mg/kg. Means and SD are 4.67 ± 3.11 (n= 1393), 2.87 ± 2.53 (n= 975), 3.43 ± 2.11 (n= 410) for Colombia, Ecuador and Peru respectively (unpublished data Clima-LoCa project). The percentage of samples being above the limit was 13% **(Figure 4)**. We only consider 70% chocolate here: If we calculate nickel in chocolate with a lower percentage of cocoa mass made from these beans, there would be fewer samples failing to comply.

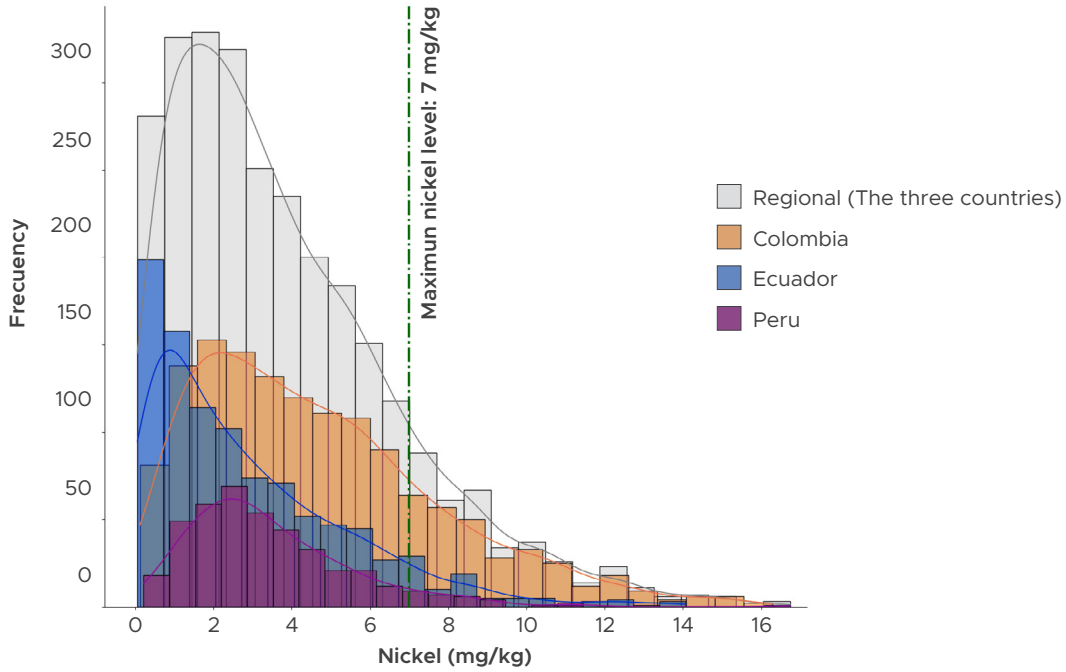

Figure 4: A frequency diagram of nickel levels in 70% chocolate calculated from beans from 2778 cacao trees from Colombia, Ecuador and Peru.

This dataset helps us understand the link between farms located on tectonic plate boundaries and levels of nickel in cacao beans. For example, we find more extreme values of nickel in Colombia compared to Ecuador and Peru (20.6%, 7.3% and 6.1% exceed the 7 mg/kg limit respectively). The highest values are found in trees growing in northern and eastern Colombia where the Caribbean plate is exposed, hotspots along the edge of the Nasca plate on the coast of Ecuador, and areas in the eastern cordillera in Peru. These all have geogenic histories leading to higher levels of nickel in the soil.

Q10 Are cacao-producing areas high in cadmium also high in nickel?

Cadmium is another heavy metal that has been actively regulated in chocolate and derivatives since 2019.[21] Unlike nickel, cadmium is not essential to the cacao tree. Studies have shown that cadmium levels in cacao from parts of Latin America is higher than other regions of the world. This is due to areas with naturally high levels of cadmium in the young soils found there [22,30]. So far, the data do not suggest that chocolate from Latin American cacao has higher levels of nickel than chocolate from other regions.

Q11 Is it possible to reduce nickel levels in chocolate?

In the farm: As for many metals nickel solubility, and therefore availability, to plants increases with decreasing soil pH and cationic exchange capacity [3,23]. This suggests that if the soil is acidic and has high levels of nickel it may help to lime the soil. This may even help increase productivity. However, as the tree needs nickel it may not be this simple to manipulate and further research is therefore needed. Additionally, care should be taken when aplying silicates as soil improvement or as a carbon removal technology [29]. Prior testing is recommended as silicates can have high levels of nickel and other heavy metals.

Post-harvest bean mixing: One of the most effective and rapid solutions for ensuring that the EU limits for cadmium are met has been through mixing of cacao from different regions, while ensuring the quality, including organoleptic characteristics [24]. To achieve this, monitoring of the heavy metal at the level of farm harvests, or at centres of post-harvest after fermentation and drying, or even in commercial lots has proven to be helpful in ensuring correct mixes. For chocolate makers who are focussed on single-origin, for their product and whose focal area is located in zones overlapping with areas of ultramafic soil, we suggest it may be useful to map and monitor nickel levels. We do not foresee this as an issue for chocolate makers who purchase beans from wider areas.

Changing chocolate recipes: The primary source of nickel in chocolate is from the non-fat cocoa solids. It is not present in sugar, dairy milk or cocoa butter [15,25]. Removal of the cacao husk during winnowing can reduce nickel by 10-20% compared to levels in the unshelled bean [25]. However, adding nuts or plant-based milk to the bar may increase nickel in the final product [26]. This means that while white chocolate made with dairy milk will not contain nickel, it may if it is made with plant-based milk. Nickel may also be a process contaminant of hydrogenated fat. When hydrogenation is carried out, a nickel catalyst is used to incorporate H into unsaturated fats [27]. Thus, the level of nickel in the chocolate bar thus depends on the recipe and will be proportional to the percentage of cocoa mass: the lower the percentage in the bar, the lower the concentration of nickel compared to the cacao bean [17,25].

Q12 What research needs to be done next?

It seems unlikely that the maximum levels of nickel for chocolate and derivatives that came into effect on 1 July 2025 will be problematic for the sector, but there may be some localized areas where, due to underlying geology, cocoa beans have high nickel levels. For those chocolate makers who make single origin, or bean-to-bar chocolate it will be important to understand where the farms are located. It may be useful to map nickel levels in farms to understand how to mix beans or adapt recipes to ensure that the EU regulation can be met.

As plants require nickel, there is likely to be a genetic basis for its uptake. Peru has been identified as the cradle of cacao domestication and the genetic diversity found there may be interesting for screening for nickel accumulation.

The expert panel of the European Food Safety Authority also recommends the need for more monitoring of nickel in food within the EU from 2025-2027, including chocolate and cacao. It suggests that member states work hand in hand with the food sector, following monitoring protocols in Regulation (EC) No 333/2007. It also suggests the need to gather knowledge on measures to reduce nickel levels in food and to promote these for implementation by farmers and the food sector (regulation [EU] 2024/907) [8].

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Clima-LoCa is a regional project led by the Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT), implemented with research partners from Latin America and Europe and funded by the European Commission. This project contributes to the objectives of the 2018 call for "Climate-Relevant Innovation through Research in Agriculture" of the EC-led platform DeSIRA (Development-Smart Innovation through Research in Agriculture), based on the ambition to improve research mobilization and innovation capacity contributing to the sustainable development of the cacao sector.

This project addresses important challenges related to the resilience, competitiveness, and inclusiveness of the growing cacao sector. Here, resilience refers to the capacity of smallholder producers, and other value chain actors, to mitigate the negative impacts of new EU food safety regulations on cadmium in cacao, and of climate change. The project builds on the premise that agricultural innovations require engagement of diverse end users to co-develop context-relevant production systems and practices based on strong interdisciplinary science, while creating an enabling environment for their adoption and scaling.

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Acknowledgements

We would like to acknowledge help of Daniela Bertoldi, Ruth Vanderschueren, David Romero-Estévez and Tewodros Godebo in providing the raw data from their publications for this analysis.

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*Bioversity International and CIAT are part of the Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT)

Correct citation

Atkinson R; Chavez E; da Silva M; Dekeyrel J; Giraldo MC; Martín JM; Pulleman M; Smolders E; Taborda D; Thomas E. (2025). Nickel: the new EU food safety regulation and what it means for the cacao and chocolate sector. Clima-LoCa briefing note number 5. Bioversity International and CIAT. 11 p. https://hdl.handle.net/10568/175442

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