Factsheet of the IDF n° 28/2023

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Fédération Internationale du Lait · International Dairy Federation · FIL IDF

Prevention of the development of chlorates in the dairy chain

Scientific excellence
Industry applicability
Strategic networking
Global influence

Background

Chlorate (ClO3-) is a significant degradation product of chlorine-based disinfectants. It arises largely from chlorine-based products that are widely used in water disinfection processes designed to produce microbiologically-safe potable water. Chlorate also arises from the use of such products for cleaning and disinfection of milk- and food-contact surfaces along the manufacturing chain from farm to table.

Occurrence in milk and dairy products

Where appropriate prevention measures are not followed, many food types, including dairy products and dairy ingredients, may be considered as dietary contributors. Chlorate levels may be especially elevated where municipal chlorinated water is used as an ingredient with subsequent evaporation or concentration steps; or where processing aids such as salts and strong bases containing chlorine are used, e.g., whey powders and milk protein concentrates.

Toxicity, exposure and human health risk

Perchlorate (ClO4-) and, to a lesser extent, chlorate can both have an adverse effect on iodine uptake by the thyroid gland, causing reduced production of thyroid hormones and hypothyroidism. Iodine deficiency can lead to irreversible neurodevelopmental toxicity (cretinism) at the early stages of human life. Population groups most vulnerable to iodine deficiency include pregnant women, infants, small children, and people with deficient iodine intake or a pre-existing thyroid disease. Scientific opinions from the European Food Safety Authority (EFSA) and the Joint FAO/WHO Expert Committee for Food Additives (JECFA) adopt slightly different risk assessment methodologies and have drawn different conclusions. JECFA has noted that the dietary exposure to chlorate is compatible with the exposure permitted within the WHO drinking water guidelines and set a tolerable daily intake (TDI) of 10 µg/kg body weight (bw)/day. EFSA has expressed the view that dietary exposure of infants and toddlers to chlorate exceeds stated food safety guidance values (TDI 3 µg/kg bw/day). However, applying the recently published EFSA guidance on the use of Benchmark Dose (BMD) modeling, Haber et al. (2021) recently derived a TDI of 80 µg/kg bw/day for chlorate. Also in 2022, ANSES – the French Agency for Food, Environmental and Occupational Health & Safety - conducted an assessment and established an updated TDI for perchlorate of 1.5 µg/kg bw/day (ANSES, 2022). This TDI equates to 15 µg/kg /kg bw/day for chlorate.

Legislation and maximum residue limits

Most of the discourse and activity relating to chlorate in foods emanates from the European Union (EU), where the use of chlorate as a pesticide, specifically for herbicidal uses, has been banned on occupational health and safety grounds since 2008. From 2020, maximum residue limits (MRLs) for pesticides apply in the EU to selected commodities, while the default MRL of 0.01 mg/kg (as consumed) remains valid for all foods not mentioned in the regulation 2020/749 including foods for infants and young children (European Commission, 2020). Meanwhile, many countries outside of the EU require the use of chlorine as an effective disinfecting agent for household water supplies, and have not determined it as a risk to humans. Alongside Europe, only the New Zealand Ministry for Primary Industries (MPI) has established MRLs for chlorate in infants and follow-on formula powder of 0.4 mg/kg and 0.8 mg/kg as powder, respectively. These MRLs will apply from July 2023. These risk-based MRLs are derived from the 2008 JECFA acceptable daily intake (ADI) of 10 µg/kg body weight/day for chlorate.

Although a chlorate MRL for foods is established, chlorine-based water treatment and chlorine-based cleaners and sanitizers are still allowed in the EU, for use on farms and in food plants, although in several EU countries such use is discouraged. Chlorination of drinking water is recommended by WHO and they have set a provisional guideline value of 0.7 mg/L for chlorate in potable water (World Health Organization, 2017). Different regulatory approaches have been taken for drinking water in different countries, with the EU, China, Canada, Australia, and New Zealand setting either limits for chlorate, or chlorite (ClO2-), or both.

Control

It is critical that prevention and control of chlorate are addressed without compromising microbial hygiene, which is of prime importance to delivering water and food products that are safe for consumption. Generally, preventing or mitigating chlorate occurrence is necessary as the removal of chlorate, once present, is impractical at later stages in the food manufacturing process. Effective practices that minimize chlorate development have been identified along the entire production chain from on-farm milking through to the processing of dairy ingredient/product at manufacturing plants:

- Water usage is the most critical entry point of chlorate, and thus a good understanding of municipal water origin and disinfection processes is highly recommended. In dairy plants, any type of water (whether municipal, deep well or surface) should be considered as an ingredient and evaluated by a hazard analysis and critical points (HACCP) process. Chlorine dioxide (ClO2) is used to disinfect water at some processing plants. If chlorine dioxide is generated on-site, then it should be used immediately and accurate chlorine dosing is recommended to avoid excess of any one reagent leading to chlorate formation. According to WHO guidelines for drinking water, residual chlorine of a few tenths of a milligram per litre are normal levels to act as a preservative during distribution (World Health Organization, 2017).

- Chlorate formation from hypochlorite disinfectant, incorporated into milking equipment cleaning protocols on-farm, can be difficult to control due to the large number of milk-producing sites (individual farms). Chlorate formation from hypochlorite disinfectants is reduced by managing its quality and storage conditions: pH, concentration, duration and temperature of storage, and exposure to (sun)light (Stanford et al., 2011).

- At farm level, the safety and quality of ruminants' drinking water is critical in keeping the ruminants healthy, resulting in the production of a safe milk stream. Use of chlorine-based cleaners and sanitizers should be minimized to the extent practical, and always rinsed properly after use.

Detection methods

Quantitative determination of chlorate at low concentrations is carried out by liquid chromatography tandem mass spectrometry (LC–MS/MS). There are some challenges to avoid interferences from both dairy components, as well as from substances that can migrate from laboratory materials. Global standardisation efforts have recently resulted in the adoption of a First Action Method by the Association of Analytical Chemists (AOAC International, 2022). In a modern food supply chain, residue monitoring through regular sampling and analysis is an important step as part of a properly safeguarded process.

Conclusion

While dairy product manufacturers must be mindful of their responsibilities to consumers to produce food that is safe to eat and endeavour to meet low chlorate level requirements, it is absolutely critical that dairy foods are microbiologically-safe, and that microbiological quality is not compromised in any way.

Acknowledgments

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