Executive Summary - Microcystins in Fish

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During the Summer and Autumn of 2023, Lough Neagh in Northern Ireland was affected by a cyanobacterial bloom. Testing of water from within the bloom reported high concentrations of one type of cyanobacterial toxin, microcystins.

Samples were taken from the Lough of eels, roach, perch, pollan and bream and tested for a range of cyanobacterial toxins, including microcystins, nodularins, anatoxin, cylindrospermopsin and saxitoxin. Each sample comprised 10 fish, and five samples were taken of each species, except for bream for which a single sample was collected. The fish were dissected and the edible flesh, intestine, liver, roe, gonad and/or gills analysed separately. Microcystins were detected at a range of concentrations in the various parts of the fish that were sampled - intestine, liver, roe and/or gills, but were not detected in the edible flesh of any of the fish samples. Averaged across the samples, the highest concentrations of microcystins were quantified in the intestine samples, followed by the liver samples, with low concentrations were detected in the gills and a small number of the samples of gonads and roe. None of the other toxins were detected in any fish sample.

The initial analysis for microcystins was of free toxins only. However, there is evidence that microcystins which are covalently bound to proteins are also bioavailable and therefore 22 fish tissue samples, including nine fish flesh samples, were also sent to another laboratory where they were analysed by a method which measures the total concentrations of microcystins, free and protein-bound. The viscera tissue samples chosen for the further analysis were those with the highest concentrations of the free toxins, while the fish flesh samples included 2-3 samples each of eels, roach, pollan and perch. The concentrations of total microcystins found in viscera samples were around one order of magnitude higher than the concentrations of free microcystins that had been measured. However, microcystins were still not detected in the edible fish flesh samples.

It is possible that microcystins were not present at any level in any of the fish flesh samples. However, the presence of microcystins in the edible flesh of fish has been reported in the scientific literature, albeit at lower levels than those in the gastrointestinal tract or other parts of the viscera such as liver (Testai et al., 2016). Since microcystins were detected in other parts of the fish sampled from Lough Neagh it is also possible that they were also present in the fish flesh but at levels below the limits of detection of the analytical methods. The limit of detection of the analytical method for total (free + bound) microcystins was 10 µg/kg wet weight.

An upper bound dietary exposure assessment was conducted. While a lower bound exposure assessment would assume the microcystins were not present in the edible flesh, i.e. a concentration of 0 µg/kg, the upper bound approach assumed they were present at the limit of detection of 10 µg/kg. The true concentrations may be between these levels. The exposure assessments consider high consumers of fish (97.5th percentile). For eels, consumption data

were used from the National Diet and Nutrition Survey (NDNS). For roach, perch, pollan and bream. No consumption data were available from the NDNS and consumption data for trout were used instead as a proxy.

The main target organ for toxicity of the microcystins is the liver, though other organs may also be affected. The microcystin most studied toxicologically is microcystin-LR, which is one of the most common microcystins. A WHO review established a provisional tolerable daily intake (TDI) for microcystin-LR of 0.04 µg per kg bodyweight (bw). WHO recommended that exposures to total microcystins should be compared to this provisional TDI, though there is uncertainty with this as individual microcystins are likely to differ significantly in their toxic potencies.

Estimated dietary exposures of total microcystins were all within the provisional TDI, indicating no health concern from consuming the edible flesh of these species.

Since fish may be caught and prepared for consumption not only by food business operators but by recreational anglers, concern has been raised that evisceration may be incomplete or the edible flesh may become contaminated in the process, and therefore this was also considered in the risk assessment. This was based on the sample of fish which contained the highest concentration of total microcystins in a viscera component, which was a sample of roach with a particularly high concentration of microcystins in intestine. It was assumed that 10% of the relative proportion of intestine to flesh in the fish would be inadvertently consumed with the flesh. In this scenario, dietary exposures would be within the provisional TDI in most age groups or would marginally exceed the TDI, but this would not be toxicologically significant. In addition, since this exposure scenario used an upper bound approach to the concentration in flesh, and used the highest concentration in any viscera sample, it is not clear that there would be any exceedance of the provisional TDI in practice. Overall, it appears unlikely that consumers will substantially exceed the provisional TDI on a long-term basis due to incomplete evisceration of fish.

Overall, exposure to microcystins from eating the edible flesh of the tested fish species would not be expected to cause adverse effects in consumers, including if the fish is inadequately eviscerated. Therefore, we consider the **frequency of adverse reactions in the general population to be negligible**, so rare that it does not merit to be included.

Based on the possible levels of exposure to microcystins from fish from Lough Neagh, it is considered that any liver injury, were it to occur in consumers of fish, would result from long term exposure and be mild. Overall, we consider the severity of illness that could potentially occur as a result of exposure to microcystins from consuming edible fish flesh from Lough Neagh to be **medium** (i.e. moderate illness, incapacitating but not usually life-threatening and of moderate duration).

We consider the **level of uncertainty to be medium** (i.e. there are some but no complete data available), but that this does not affect the conclusion of the risk assessment since many of the key uncertainties are addressed within the risk assessment. However, future monitoring would be useful to assess whether microcystin concentrations in the fish change over time.