Vitenskapskomiteen for mattrygghet
Norwegian Scientific Committee for Food Safety

Opinion of the Panel on Animal feed of the Norwegian Scientific Committee for Food Safety
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Assessment of krill meal in animal feedingstuff with respect to fluorine

SUMMARY

The Norwegian Scientific Committee for Food Safety (VKM), Panel on animal feed recently adopted a comment on whether an increase in the maximum limit for fluorine in feed materials - phosphates and marine crustaceans such as marine krill would pose a threat to fish health or to the consumer. The Panel of Animal feed commented that available results suggest that fish tolerate high levels of dietary fluoride in the form of krill meal as krill is a natural feed source for wild fish. Due to the limited transfer of fluoride from feed into edible tissues, fluoride in food from animal origin contributes only marginally to human exposure. Increasing the maximum limit for fluorine in the form of krill meal in complete feedingstuffs is therefore not expected to pose a threat to the consumer (Opinion of the panel on animal feed, www.vkm.no).

However, terrestrial mammals are relatively sensitive to fluoride and therefore the Norwegian Scientific Committee for Food Safety (VKM), Panel on animal feed, has been requested by the Norwegian Food Safety Authority to assess the risk which may result from high levels of fluorine in krill meal if this is used as a component in feed for various terrestrial animal species.

Krill meal contains extremely high levels of fluoride and since terrestrial mammals are relatively sensitive to fluoride toxicity, a supplement of krill meal in the feed would imply a considerably increased risk for health effects in those species. Even a low percentage of krill meal (with typical fluoride contents ranging from 1000 to 3000 mg/kg) in the feed ration for terrestrial animals would increase the feed fluoride level considerably, and imply an increased risk of adverse effects in domestic mammals. Birds are less sensitive and may tolerate a moderate supplement of krill meal in the diet. Comments on fluorine in feed materials for fish have been given separately.

BACKGROUND

The Norwegian Scientific Committee for Food Safety (VKM), Panel on animal feed recently adopted a comment on the maximum levels of fluorine in feedingstuff for fish (Opinion of the panel on animal feed, VKM). The background for the comment was a request from the

Norwegian Food Safety Authority to comment whether an increase in the maximum limit for fluorine in feed materials - phosphates and marine crustaceans such as marine krill from 2000 mg kg^{-1}, 88 % dry matter to 4000 mg kg^{-1}, 88 % dry matter and complete feedingstuffs from 150 to 350 mg/kg would pose a threat to fish health or to the consumer.

The Panel on animal feed commented that available results suggest that fish tolerate high levels of dietary fluoride in the form of krill meal as krill is a natural feed source for wild fish. Since the transfer of fluoride (from feed) into edible tissues is limited, fluoride in food from animal origin contributes only marginally to human exposure. Therefore, increasing the maximum limit for fluorine in the form of krill meal in complete feedingstuffs is not expected to pose a threat to the consumer (Opinion of the panel on animal feed, www.vkm.no).

However, terrestrial mammals are relatively sensitive to fluoride and therefore the Norwegian Scientific Committee for Food Safety (VKM), Panel on animal feed, has been requested by the Norwegian Food Safety Authority to assess the risk which may result from high levels of fluorine in krill meal if this is used as a component in feed for various terrestrial animal species. The present assessment is therefore an addendum on the risk of fluorine in the feed for other domestic animal species than fish.

TERMS OF REFERENCE

The Norwegian Scientific Committee for Food Safety (VKM), Panel on animal feed, was requested by the Norwegian Food Safety Authority to assess fluorine in krill meal as feedingstuff for various animal species.

ASSESSMENT

Introduction

Flourine is one of the most abundant elements, occurring in different chemical forms in the environment and in living organisms. Fluorine is a gaseous element with a strong odour, but occurs almost exclusively in the environment in its ionic form, fluoride. Due to its high electron affinity, fluorine easily forms salts, and more than 100 fluoride minerals have been described. Fluoride is found in organic compounds in plants and animals. Soil may contain relatively high levels of fluoride. The element fluorine is considered to be essential for optimal growth, reproduction and mineralization of bone and tooth. But the intake of excessive amounts of fluoride can induce either acute toxicity or chronic disease. In animals, fluoride is mostly localised in hard tissues such as bone.

Krill are marine crustaceans. The exoskeleton of the Antarctic krill (*Euphausia superba*) and North Atlantic krill (*Meganyctiphanes norvegica*) contain high levels of fluoride (1500 mg/kg whole body dry weight) (Soevik and Braekkan, 1979). Sands et al. (1998) examined a number of Antarctic marine crustaceans and the highest fluoride concentrations were found in Euphausiids (5400 mg/kg dry weight in the exoskeleton).

Fluorine levels in feed

The current maximum level for total fluorine in complete feedingstuffs set by the EU is 150 mg/kg (88% dry weight). For complete feedingstuffs for lactating ruminants, other ruminants and pigs, the limits are 30, 50 and 100 mg/kg, respectively. The mean levels of fluorine

measured in commercial compound feed for ruminants, pigs and poultry reported by EU member states are in the range of 14-24 mg/kg. The mean corresponding level in fish feed is 30 mg/kg (EFSA, 2005).

The fluoride content in krill meal ranges from 1000 to 3000 mg/kg, most of the fluoride is associated with the exoskeleton (Julshamn et al., 2004). Krill is a natural feed for wild fish, penguins, seals and whales.

Fluoride toxicity in terrestrial animal species

Acute fluorine toxicosis is rare and often a result of accidental intake of toxic compounds such as sodium fluoride or silicon tetrafluoride. Chronic fluorine toxicosis, also called fluorosis, has an insidious development and onset. The disease is debilitating, and the point at which fluoride ingestion becomes detrimental is dependent on the amount and duration of exposure, the chemical form and solubility of ingested fluorides, variation in exposure (intermittent), animal species, age, nutritional status, health status, stress factors, exposure to other agents, and individual susceptibility (Shupe, 1972; Suttie, 1983).

Soluble fluorides as NaF and fluoride accumulated in vegetation, are easily absorbed and regarded more toxic than fluoride in the form of calcium phosphate, rock phosphate, aluminium fluoride and cryolite. Thus, fluoride in krill may be regarded as less bioavailable and thus less toxic to animals than fluoride from vegetable feedstuffs. Alternating periods of high and low fluoride exposure are more injurious than constant intake providing the same total amount.

Fluoride is taken up by mineralized tissue where F^- substitutes OH^- in the lattice of hydroxyapatite (Eanes, 1983). The detrimental effects of fluoride are on bones (osteofluorosis) and teeth (dental fluorosis). Fluoride crosses the placenta and is taken up by the foetus (Shupe and Olson, 1983). The distribution into milk is low and is of no significance to human and animal health (NRC, 1974).

Excessive fluoride exposure during tooth formation and mineralization results in teeth erupting with characteristic lesions. Dental fluorosis shows a similar gross picture in mammalian species, characterized by mottling, discolouration, pitting and erosion of the enamel, and hypoplasia and abnormal abrasion of the teeth (Shupe and Olson, 1983). Animals can have minor dental fluorotic lesions without any impairment of performance. In cattle, dental lesions have been induced at an intake of 20 mg NaF/kg in the feed (Suttie, 1983).

Osteofluorosis, also referred to as generalized fluorosis, is considered to be more serious than dental fluorosis. This type of effect can be induced at any time during life, although the metabolically active bones of young animals are particularly susceptible to the effects of excessive fluoride. The lesions are mainly located on the bone surface and are seen as a general thickening of the bones or as excessive surface formations (exostosis). Endostal proliferation may occur in severe cases. Mineralization of tendons at the point of attachment to the bone is also commonly observed (Shupe et al., 1963). The most metabolically active bones, used in locomotion, chewing or breathing are those most affected.

Birds seem less sensitive to fluoride than most other animals. As birds lack teeth, which are important in diagnosing fluorosis in other species, the assessment of fluoride toxicosis in birds is more difficult.

Emphasis has been put on the effects of fluoride on growth rate, feed consumption, bone strength, egg production and egg characteristics and reproduction (NRC,1974). As the toxic effect level of fluoride in the feed varies with a range of factors (given above), estimates of

tolerance levels must be considered arbitrary and associated with uncertainty. Vikøren (1995) has attempted to review performance tolerance thresholds for fluoride in complete feed (mg/kg dry weight) to relevant animal species. When also water contains appreciable amounts of fluoride, these values should be reduced proportionally. The tolerance levels are based on NaF or other fluorides of similar toxicity. These levels may be regarded as no observed adverse effect levels (NOAELs in the feed (mg/kg dry weight)).

Table 1: No observed adverse effect levels (NOAELs) of fluoride in feed for various animal species (mg/kg dry weight)

Animal species	NOAEL in feed (mg/kg dry weight)
Dairy cattle and heifers	40
Beef cows	50
Sheep (breeding)	60
Lambs (feeder)	150
Horses	60
Swine (growing)	70
Poultry	150-400
Dogs (growing)	100

However, other vertebrates such as penguins and seals, which rely on krill as a major part of their food source, have bone fluoride levels as high as 10 000 mg/kg dry weight, with no apparent adverse effects (Schneppenheim 1980, Culik 1987).

Risk characterization

The table above shows that terrestrial domestic mammals are in general relatively sensitive to fluoride toxicity. There is a lack of scientific literature regarding availability and toxicity of fluoride in krill meal. As a conservative approach, it is assumed that the toxicity of krill fluoride is similar to that of NaF. Even a low percentage inclusion of krill meal (with fluoride content ranging from 1000 to 3000 mg/kg) in the feed ration for terrestrial animals would increase the feed fluoride level considerably, and imply an increased risk of adverse health effects in domestic mammals. As birds are less sensitive, a moderate supplement of krill meal to poultry feed may not imply a corresponding health risk.

Carry over and human exposure

The transmission of fluoride (from feed) into edible animal products is limited, and animal products contribute only marginally to human fluoride exposure (EFSA, 2004). An increase in the fluoride content in feedingstuff for domestic animals is therefore not expected to pose a threat to the consumer.

Conclusion

Terrestrial domestic mammals are in general relatively sensitive to fluoride toxicity. There is a lack of scientific literature on the availability and toxicity of fluoride in krill meal. As a conservative approach, it is assumed that the toxicity of krill fluoride is similar to that of NaF.

Even a low percentage inclusion of krill meal in the feed ration for terrestrial animals would increase the feed fluoride level considerably, and imply an increased risk of adverse health effects in domestic mammals. As birds are less sensitive, a moderate supplement of krill meal to poultry feed may not imply a corresponding health risk.

ASSESSED BY

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