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SCIENTIFIC OPINION

Scientific Opinion on safety and efficacy of zinc compounds (E6) as feed additive for all animal species: Zinc oxide, based on a dossier submitted by Grillo Zinkoxid GmbH/EMFEMA[1]

EFSA Panel on Additives and Products or Substances used in Animal Feed (FEEDAP)[2,3]

European Food Safety Authority (EFSA), Parma, Italy

ABSTRACT

Zinc oxide is a safe source of zinc for all animal species and no concerns for consumer safety are expected from the use of zinc oxide in animal nutrition, considering the maximum contents for total zinc in feedingstuffs set by EU legislation. Zinc oxide is not an irritant to skin and eyes; it is not a skin sensitiser. The zinc oxide under application is considered a compound with high dusting potential, which may result in a critical exposure of users by inhalation, affecting the respiratory system. The authorised use of zinc oxide as a feed additive does not pose a direct concern for the agricultural soil compartment. However, there is a potential environmental concern related to groundwater, drainage and the run-off of zinc to surface water. Acid sandy soils are most vulnerable to these processes. In order to draw a final conclusion, some further refinement to the assessment of zinc-based feed additives in livestock needs to be considered, for which additional data would be required. The use of zinc-containing additives in aquaculture up to maximum authorised zinc level in feeds is not expected to pose an appreciable risk to the environment. Zinc oxide is efficacious in meeting animal zinc requirements.

KEY WORDS

Nutritional additive, compounds of trace elements, zinc, zinc oxide, safety, environment, efficacy

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1 On request from the European Commission, Question No EFSA-Q-2011-00844 adopted on 15 November 2012.
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3 Acknowledgement: The Panel wishes to thank the members of the Working Group on Trace Elements, including Noël Albert Dierick, Jürgen Gropp, Joop de Knecht, Alberto Mantovani, and the late Reinhard Kroker, for the preparatory work on this scientific opinion.

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SUMMARY

Following a request from the European Commission, the Panel on Additives and Products or Substances used in Animal Feed (FEEDAP) was asked to deliver a scientific opinion on the safety and efficacy of zinc oxide when used as feed additive for all animal species.

The FEEDAP Panel concluded that zinc oxide is a safe source of zinc for all animal species, considering the maximum contents for total zinc in feedingstuffs set by EU legislation.

No concerns for consumer safety are expected from the use of zinc oxide in animal nutrition when used up to the EU maximum authorised level in feed.

Zinc oxide is not an irritant to skin and eyes; it is not a skin sensitiser. The zinc oxide under application is considered a compound with high dusting potential, which may result in a critical exposure of users by inhalation, affecting the respiratory system.

The authorised use of zinc oxide as a feed additive does not pose a direct concern for the agricultural soil compartment. However, there is a potential environmental concern related to groundwater, drainage and the run-off of zinc to surface water. Acid sandy soils are most vulnerable to these processes. In order to draw a final conclusion, some further refinement to the assessment of zinc-based feed additives in livestock needs to be considered, for which additional data would be required. The use of zinc-containing additives in aquaculture up to maximum authorised zinc level in feeds was not expected to pose an appreciable risk to the environment.

Zinc oxide is efficacious in meeting animal zinc requirements.

The FEEDAP Panel made some recommendations (i) on the specification of zinc oxide, and (ii) on the direct incorporation of zinc oxide into compound feedingstuffs.

TABLE OF CONTENTS

BACKGROUND

Regulation (EC) No 1831/2003[4] establishes the rules governing the Community authorisation of additives for use in animal nutrition. In particular, Article 10(2) of that Regulation specifies that for existing products within the meaning of Article 10(1), an application shall be submitted in accordance with Article 7, at the latest one year before the expiry date of the authorisation given pursuant to Directive 70/524/EEC for additives with a limited authorisation period, and within a maximum of seven years after the entry into force of this Regulation for additives authorised without a time limit or pursuant to Directive 82/471/EEC.

The European Commission received a request from Grillo Zinkoxid GmbH/EMFEMA[5] for re-evaluation of authorisation, of zinc-containing additive, *zinc oxide*, when used as feed additive for all animal species (category: Nutritional additives; functional group: compounds of trace elements).

According to Article 7(1) of Regulation (EC) No 1831/2003, the Commission forwarded the application to the European Food Safety Authority (EFSA) under Article 10(2) (re-evaluation of an authorised feed additive). EFSA received directly from the applicant the technical dossier in support of this application.[6] According to Article 8 of that Regulation, EFSA, after verifying the particulars and documents submitted by the applicant, shall undertake an assessment in order to determine whether the feed additive complies with the conditions laid down in Article 5. The particulars and documents in support of the application were considered valid by EFSA as of 2 August 2011.

The additive zinc oxide had been authorised in the European Union (EU) under the element Zinc-Zn for all animal species "Without a time limit" (Commission Regulation (EC) No 1334/2003)[7] and amendments. Following the provisions of Article 10(1) of Regulation (EC) No 1831/2003 the compound was included in the EU Register of Feed Additives under the category "Nutritional additives" and the functional group "Compounds of trace elements".[8]

The Scientific Committee on Animal Nutrition (SCAN) issued an opinion on the use of zinc in feedingstuffs (EC, 2003a). EFSA issued opinions on the safety of the chelated forms of iron, copper, manganese and zinc with synthetic feed grade glycine (EFSA, 2005) and on the safety and efficacy of a zinc chelate of hydroxy analogue of zinc (Mintrex®Zn) as feed additive (EFSA, 2008a; EFSA, 2009a,b), and on the safety and efficacy of tetra-basic zinc chloride for all animal species (EFSA 2012a). EFSA has issued opinions concerning the re-evaluation (EFSA 2012b, EFSA 2012d) and a new use of zinc sulphate monohydrate (EFSA, 2012b) and the re-evaluation of zinc chelate of amino acids hydrate (EFSA, 2012c).

[4] Regulation (EC) No 1831/2003 of the European Parliament and of the Council of 22 September 2003 on additives for use in animal nutrition. OJ L 268, 18.10.2003, p. 29.

[5] Grillo Zinkoxid GmbH/EMFEMA. Halberstädter Strasse 15. 38644-Goslar. Germany. This application involves three companies: Grillo Zincoxid GmbH, Ferro Industrias Química and Umicore Nederland B.V. During the course of the assessment, EFSA was informed by the applicant that company Ferro Industrias Químicas was withdrawn from the application.

[6] EFSA Dossier reference: FAD-2010-0072

[7] Commission Regulation (EC) No 1334/2003 of 25 July 2003 amending the conditions for authorisation of a number of additives in feedingstuffs belonging to the group of trace elements. OJ L 187, 26.7.2003, p. 11.

[8] European Union Register of Feed Additives pursuant to Regulation (EC) No 1831/2003. http://ec.europa.eu/food/food/animalnutrition/feedadditives/comm_register_feed_additives_1831-03.pdf

TERMS OF REFERENCE

According to Article 8 of Regulation (EC) No 1831/2003, EFSA shall determine whether the feed additive complies with the conditions laid down in Article 5. EFSA shall deliver an opinion on the safety for the target animals, consumer, user and the environment and the efficacy of zinc oxide, when used under the conditions described in Table 1.

Table 1: Description and conditions of use of the additive as proposed by the applicant Grillo Zinkoxid GmbH/EMFEMA

Additive	zinc oxide
Registration number/EC No/No (if appropriate)	215-222-5
Category(-ies) of additive	3. Nutritional additives
Functional group(s) of additive	b. Compounds of trace elements

Description			
Composition, description	Chemical formula	Purity criteria (if appropriate)	Method of analysis (if appropriate)
zinc oxide	ZnO	min 88%	DIN 55908:1998-07; ISO 27085:2009-04; ISO 11969:1996-07; ISO 9298:1995-11

Trade name (if appropriate)	
Name of the holder of authorisation (if appropriate)	

Conditions of use				
Species or category of animal	Maximum Age	Minimum content	Maximum content	Withdrawal period (if appropriate)
		mg/kg of complete feedingstuffs		
all species		150	250	

Other provisions and additional requirements for the labelling	
Specific conditions or restrictions for use (if appropriate)	Can only be used through a premixture (Article 13, point 1, Council directive 96/51/EC of 23 July 1996 amending Directive 70/524/EEC concerning additives in feedingstuffs)
Specific conditions or restrictions for handling (if appropriate)	If handled uncovered, arrangements with local exhaust ventilation should be used if possible. Wear personal protective clothing. When using do not eat, drink, smoke, sniff. Avoid: Generation of dust. Depositing of dust. Protect drains and sewers from entry of the product. Provide for retaining containers, e.g. floor pan without outflow. Keep in locked storage or only make accessible to specialists or their authorised assistants. Containers have to be labelled clearly and permanently.
Post-market monitoring (if appropriate)	There is no need for specific requirements of post-market monitoring. It is recommend to conduct post marketing monitoring in compliance with EU law on feed hygiene, namely by use of HACCP and traceability systems, and formal monitoring of customer feedback through product or service complaints.
Specific conditions for use in complementary feedingstuffs (if appropriate)	To supply Zn in final feeds within EU legal limits for each species.

Maximum Residue Limit (MRL) (if appropriate)			
Marker residue	Species or category of animal	Target tissue(s) or food products	Maximum content in tissues

ASSESSMENT

At the time of submission the application represented three companies. At present only companies Grillo Zincoxid GmbH and Umicore Nederland B.V. are involved in the application. The opinion is based on data provided by the two companies involved in the production/distribution of zinc-containing compounds, and publicly available literature. It should be recognised that this data covers only a fraction of the existing zinc oxide additives placed on the market.

1. Introduction

The transition metal zinc is essential to all living organisms. It is an integral component of an estimated 10 % of all proteins, in which it contributes to tertiary structure or catalytic activity covering all enzyme classes. It is also a signalling substance in that it functions as second messenger and synaptic neuromodulator. The biological functions of zinc are numerous and diverse and include glucose and lipid metabolism, cell proliferation, embryogenesis and those related with the nervous and immune systems. The roles of zinc, its deficiency and toxicity symptoms in farm animals have been described in a previous opinion of the Scientific Committee on Animal Nutrition (EC, 2003a), and a brief update on normal functions and toxicity of zinc is given in Appendix B. To the knowledge of the FEEDAP Panel, there is no additional relevant information that may lead to reconsideration of that opinion.

The additive under assessment is zinc oxide for use in feed for all animal species/categories. This compound is already authorised in the European Union (EU) as a nutritional feed additive and foreseen for re-evaluation.

A compilation of risk assessments carried out on zinc and its compounds, including opinions from EFSA Panels other than the FEEDAP Panel, is in Appendix C. A list of authorisations of zinc compounds in the EU, other than as feed additive, is reported in Appendix D.

EFSA commissioned two studies, from which technical reports have been delivered; information from these reports has been used in this opinion. One of the studies was done on selected trace and ultratrace elements in animal nutrition by the University of Gent (Belgium) (Van Paemel et al., 2010); zinc was included in this study. The other study concerned the pre-assessment of the environmental impact of zinc and copper used in animal nutrition (Monteiro et al., 2010).

2. Zinc oxide

For compounds of trace elements, the element itself is considered the active substance.

2.1. Characterisation and identity

Zinc oxide (Chemical Abstracts Service (CAS) no 1314-13-2) has the chemical formula ZnO (molecular weight 81.34 g/mol, theoretical maximum zinc content: 80.35 %).

The product is a solid, white to dark green or beige/brownish powder, odourless, with very low solubility in water (1.6 mg/L at 20°C). It has a density of 5610 kg/m^3, and bulk density ranges from 1500 to 2400 kg/m^3.

Feed grade zinc oxide is manufactured starting with zinc bearing materials, such as zinc ashes or other zinc remains. The zinc material is filled in a rotary kiln (a cylindrical vessel, which rotates slowly about its axis) and heated. During the process, the contaminants lead and cadmium are transformed to their respective chloride salts which are subsequently removed as gases (at temperatures above 960 ºC. The resulting zinc oxide is milled, sieved and packed.

The purity of the compound is specified by the applicant to 88 % which corresponds to a zinc content of 70.7 %. Analyses of six batches (three per company) showed zinc concentrations of 73.1 to 75.7 %

corresponding to purities between 91.0 and 94.3 % zinc oxide. The main impurities are iron, aluminium and calcium as oxides, however not quantified.

The values for heavy metals and arsenic, dioxins and the sum of dioxins plus dioxin-like PCBs analysed in six batches (three batches per company) are well below the thresholds established by Directive 2002/32/EC. Control methods are in place.

Data for particle size were provided for one batch per company. The fractions below 63 µm (US sieve system) constituted between 50 % and 64 % of the product. Dusting potential (Stauber-Heubach method) was determined to be 2.0 and 5.2 g/m³ for one batch of each company.[9]

2.2. Stability and homogeneity

Stability data are not required for inorganic compounds of trace elements. A shelf life of two years is proposed by the applicant, provided it is stored under dry conditions in closed original packing. An ongoing stability monitoring in accordance with ICH Q7A chapter 11.5[10] is in place.

Homogeneity data were derived from the analyses of ten subsamples each of commercially prepared mixtures, a complementary feed (mineral feed for sows) and a premixture (not further defined). The coefficient of variation of the zinc content in the complementary feed (mean 3.5 g Zn /kg) was 12.3 %, and in the premixture (intended 40 g Zn/kg) 8.6 %.[11]

2.3. Physico-chemical incompatibilities in feed

According to the current knowledge, no incompatibilities resulting from the use of zinc in compound feed are expected, other than those widely known and considered by feed manufacturers in diet formulation.

2.4. Conditions of use

According to the applicant the zinc compound under application, zinc oxide, is intended to supply zinc in final feed for all species. Conflicting information is found in the application: one document proposed a minimum content of 150 and maximum of 250 mg Zn/kg complete feed; the maximum contents mentioned in another document (without minimum content) comply with the current legislation.[12]

2.5. Evaluation of the analytical methods by the European Union Reference Laboratory (EURL)

EFSA has verified the EURL report as it relates to the methods used for the control of zinc (seven compounds, including zinc oxide) in animal feed. The Executive Summary of the EURL report can be found in the Appendix A.

3. Safety

3.1. Safety for the target species

Zinc is recognised to be of low to moderate oral toxicity in farm animals. The National Research Council (NRC, 2005) evaluated the maximum tolerable zinc concentration in several animal species and found this to be 250 mg/kg for fish, 300 mg/kg for sheep, 500 mg/kg for cattle and poultry and 1000 mg/kg for pigs. By interspecies extrapolation, the NRC derived maximum tolerable

[9] Tecnical Dossier/Supplementary Information.
[10] Guidance for Industry Q7A. Good Manufacturing Practice Guidance for Active Pharmaceutical Ingredients. http://www.fda.gov/downloads/regulatoryinformation/guidances/ucm129098.pdf
[11] Tecnical Dossier/Supplementary Information.
[12] Maximum zinc total content in feedingstuffs set out in Commission Regulation (EC) No 1334/2003. (All figures refer to mg Zn/kg complete feedingstuff). Pet animals: 250; Fish: 200; Milk replacers: 200; Other species: 150.

concentrations of 500 mg/kg for equine species and rodents. The few data available for pets allow only a conservative approximation of the maximum tolerable dietary level, which may be 500 mg/kg diet. Consequently, the margin of safety (maximum tolerable concentration/maximum content of zinc authorised in feed) varies between species: 1.25 for fish, 2 for sheep, 3.3 for cattle and poultry and 6.7 for pigs. For the species with incomplete datasets the margin of safety is about 3 for equine species and rodents and about 2 for pets. Regarding the tolerance level for fish, the FEEDAP Panel notes that literature reports markedly different values for different species, i.e. < 100 mg/kg for tilapia (*Oreochromis niloticus*) and > 2000 mg/kg for carp (several species) and rainbow trout (*Oncorhynchus mykiss*) (Clearwater et al., 2002).

3.1.1. Conclusions on the safety for the target species

The FEEDAP Panel concludes that zinc oxide is a safe source of zinc for all animal species, considering the maximum contents for total zinc in feedingstuffs set by the EU.

3.2. Safety for the consumer

The Scientific Committee on Food (SCF) derived a tolerable upper intake level (UL) of 25 mg/day for adults and of 13 mg/day for 7-10 years children (EC, 2003b). The UL was based on a depressed copper uptake and an altered lipid profile in humans. An uncertainty factor of 2 was applied owing to the small number of subjects included in relatively short-term studies but acknowledging the rigidly controlled metabolic experimental conditions employed.

3.2.1. Metabolic and residue studies

The metabolic behaviour of zinc has been discussed in detail by the SCF (EC, 2003b) and it has been briefly described, including zinc tissue distribution, by the FEEDAP Panel (EFSA, 2008a): "Within the range of homeostatic regulation, tissue storage of zinc increases only slightly as dietary zinc increases, this not being the case in the presence of excessive amounts of the metal (NRC, 1980). In general, the zinc content of liver, kidney and muscles remains low when zinc is used about requirement levels; however, with additional zinc intake within authorised levels, zinc content in liver and kidney is increased while muscle zinc remains essentially unchanged (Jenkins and Hidiroglou, 1991)." To the knowledge of the FEEDAP Panel, no new data that would modify that statement have become available.

3.2.2. Toxicological studies

The toxicological properties of zinc have been discussed in detail by the SCF (EC, 2003b). It exerts low oral acute toxicity resulting in gastrointestinal distress with clinical signs of nausea, vomiting, abdominal cramps and diarrhoea (at 2–8 mg/kg body weight per day in different species). Some positive results in genotoxicity tests were observed. In the view of the SCF, the weight of evidence from the *in vitro* and *in vivo* genotoxicity tests supports the conclusion that zinc, notwithstanding some positive findings at chromosome levels at elevated doses, has no biologically relevant genotoxicity activity (reviewed by the World Heath Organization: WHO, 2001). This conclusion is supported by US Agency for Toxic Substances and Disease Registry (ATSDR, 2005).

One of the most sensitive and well-described effects of chronic excess zinc intake is a depressed copper uptake with associated copper deficiency effects (reviewed by Maret and Sandstead, 2006). This effect is reflected in the UL set by the SCF (EC, 2003b) of 25 mg Zn/day.

3.2.3. Consumer exposure assessment

The SCF described the mean zinc intake of the European population as to be between 7.5 and 12 mg Zn/day, based on nutritional surveys (EC, 2003b). The 97.5th percentile in some countries (Austria, Ireland) was estimated to be higher than 20 mg and close to the UL, but this was not considered a matter of concern by the SCF. The SCF data, although collected in the 1990s, appear to describe a currently valid scenario when compared with more recent data (Flynn et al., 2009; Rubio et al., 2009; Turconi et al., 2009).

A 2008 German consumption survey (Bundesministerium für Ernährung, Landwirstchaft und Verbraucherschutz, 2008) found that the median daily zinc intake among adult Germans was 11.6 and 9.1 mg in men and women, respectively. The corresponding 95th percentiles were 20.2 and 15.1 mg. Data for zinc intake in children (6–11 years) were taken from a European study, (KIGGS Modul EsKiMo; Mensink et al., 2007). The median zinc daily intake of boys aged 6–11 years was 7.4–8.7 mg and that for girls of the same age group 7.1–8.3 mg. The upper 95th percentiles were 13.1 and 12.6 mg for boys and girls, respectively; the FEEDAP Panel notes that the figure for boys equals the UL set for children by the SCF (EC, 2003b).

In all consumer groups, tissues and products of animal origin contributed to about 40–50 % of total zinc intake. Since the practice to supplement animal feed with zinc-containing compounds has not essentially changed during the last decade, it is reasonable to assume that food of animal origin recorded in the above-mentioned consumption surveys originated from food derived of animals fed zinc-supplemented diets. Since zinc oxide has been used among other zinc compounds to supplement feedingstuffs, the continued use of zinc oxide in animal nutrition would not modify consumer exposure to zinc.

3.2.4. Conclusions on safety for consumers

No concerns for consumer safety are expected from the use of zinc oxide in animal nutrition when used up to the EU maximum authorised level in feed.

3.3. Safety for the users/workers

Zinc oxide is frequently used as a constituent in a variety of creams and ointments intended to be used for treatment of minor skin irritation including specific types of nappy rash, and for protection from sun exposure. The Scientific Committee on Cosmetic Products and Non-Food Products intended for Consumers (EC, 2003c) concluded that zinc oxide is (i) not an irritant to skin based on studies in rabbits, mice and Guinea pigs, (ii) not irritating to eyes based on a test with rabbits and (iii) is not a sensitiser to the skin based on a maximisation test with Guinea pigs.

The zinc oxide under application is considered a compound with high dusting potential, which may result in exposure of users by inhalation. Exposure to high concentrations will affect the human respiratory system (Kim et al., 2006; Tal et al., 2006). In the view of the FEEDAP Panel it would be prudent to take measures to avoid exposure by inhalation.

3.4. Safety for the environment

During the use of zinc-containing feed additives, zinc is unavoidably released into the environment. When used in livestock, zinc excreted in the faeces will enter the soil environment when the faeces are applied, as a fertiliser to land, in the form of manure, slurry or litter. This might present two main potential risks:

- zinc accumulation within the topsoil to concentrations posing potential toxic risks to soil organisms;
- leaching of zinc from soil to surface waters in concentrations posing potential toxic risks to organisms resident in the water column and bottom sediments.

When used in aquaculture, trace elements such as zinc may be released directly to the broader aquatic environment around an aquaculture facility or be taken up by fish and then excreted into the environment. As stated in the EFSA technical guidance (EFSA, 2008b), the compartment of concern for fish farmed in cages is assumed to be the sediment, whereas for fish farmed in land-based systems the effluent flowing to surface water is considered to pose the main environmental risk.

EFSA commissioned a study on the environmental impact of zinc and copper used in animal nutrition (Monteiro et al., 2010). The results of this study were used as the basis for the present opinion.

To assess the potential risks for zinc used as additive in feed for terrestrial animals a model was used, which integrates the physicochemical and hydrological processes that determine the accumulation and leaching of metals in soil. Input rates of metals due to use of feed additives and land spreading of animal manure were based on the maximum allowable metal contents of feed additives for different livestock types based on maximum allowable rates of nitrogen input of 170 kg/ha/yr. Calculation of concentrations in surface water (as dissolved metal) and sediment (as total sediment metal) was done based upon the Forum for the Coordination of Pesticide Fate Models and Their Use (FOCUS) scenario methodology and considering the speciation in the environment. More specific information on the parameterisation and assumption made is given in the report.

The Predicted No Effect Concentrations (PNECs) for the different compartments were calculated following the same methodologies as presented in the EU risk assessment report for zinc by correcting for bioavailability based on the assumed soil and water chemistry of the different scenarios. Likewise, it was decided to use the added PNEC approach for zinc.

The environmental risks of zinc arising from aquaculture were assessed using the exposure models recommended in the technical guidance (EFSA, 2008b). The estimated concentrations in surface water resulting from the use of zinc as feed additives for different fish species farmed in raceways, ponds, tanks and recirculation systems and the estimate concentration in sediment arising from the use of feed additives in sea cage were all below the PNEC and therefore do not give rise to concern.

Concerning terrestrial environment, the Predicted Environmental Concentrations (PECs) in soil simulated over period of 50 year of manure application did not exceed the PNEC for terrestrial species in any model scenario developed. This is in accordance to the finding of De Vries et al. (2004), who calculated future zinc concentration after 100 years based on geo-referenced data on zinc inputs and calculated uptake and leaching.

For the water compartment, a potential risk was identified for one drainage scenario and two run-off scenarios. Two of these scenarios represent acidic soil types (i.e. an acidic sandy soil and acidic sandy loam). For these scenarios the surface water PNEC is predicted to be exceeded by a factor of 3 after 10 years by the continuous application of any manure type, and up to a factor of 5 after 50 years.

Predicted concentrations in the sediments of receiving waters, derived from erosion of metal-enriched particles and transport in drainage and runoff, responded dramatically to increases in zinc inputs due to manure application. Potential risks were predicted after ten years continuous application for all FOCUS scenarios identified in the EFSA Guidance (EFSA, 2008b) and all manure types. In most cases PNEC is exceeded by more than a factor of 10, especially for acidic soil types. In the view of the FEEDAP Panel, these findings should be treated with caution as further refinements are feasible, e.g. by taking into account the surface water chemistry of the locations of the FOCUS scenarios, more updated bioavailability models, resuspension and washout of deposited sediment and chemical transformation of trace elements in the sediment following deposition (i.e. formation of acid volatile sulphide and metal sulphides).

The FEEDAP Panel is also aware that the environmental impact of zinc is also under scrutiny within the EU framework on Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH).[13] Therefore, additional data submitted to the European Chemicals Agency (ECHA) may support further refinement of PNECs for the different environmental compartments for the assessment of zinc in animal nutrition.

[13] Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC. OJ L 396, 30.12.2006, p. 1.

3.4.1. Conclusions on safety for the environment

Based on the assessment above, the authorised use of zinc oxide as a feed additive does not pose a direct concern for the agricultural soil compartment. However, there is a potential environmental concern related to groundwater, drainage and the runoff of zinc to surface water. Acid sandy soils are most vulnerable to these processes. In order to draw a final conclusion, some further refinement to the assessment of zinc-based feed additives in livestock needs to be considered, for which additional data would be required.

The use of zinc-containing feed additives in aquaculture up to maximum authorised zinc level in feeds is not expected to pose an appreciable risk to the environment.

4. Efficacy

The use of zinc oxide in animal nutrition is extensively documented in scientific literature. It is recognised as an efficacious source of zinc in meeting animal requirements. Jongbloed et al. (2002) reported a relative bioavailability of zinc oxide, in comparison to zinc sulphate of 92 % (range 82–110), of 67 % (range 36–105) and 98 % (range 93–101) for pigs, broilers and ruminants, respectively. Edwards and Baker (1999) found that bioavailability of different feed-grade zinc oxide sources in chicks varied from 22 to 91 % when compared to zinc sulphate and suggested that the use of high temperature (1200 °C) in the production process (e.g. Waelz process) may contribute to the lower bioavailability of some feed grade sources of zinc oxide. Thus, bioavailability of zinc oxide, relative to zinc sulphate, may differ between animal species but, more importantly, there seem to exist substantial differences in bioavailability between different zinc oxide sources.

5. Post-market monitoring

The FEEDAP Panel considers that there is no need for specific requirements for a post-market monitoring plan other than those established in the Feed Hygiene Regulation[14] and Good Manufacturing Practice.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The FEEDAP Panel concludes that zinc oxide is a safe source of zinc for all animal species, considering the maximum contents for total zinc in feedingstuffs set by EU legislation.

No concerns for consumer safety are expected from the use of zinc oxide in animal nutrition when used up to the EU maximum authorised level in feed.

Zinc oxide is not an irritant to skin and eyes; it is not a skin sensitiser. The zinc oxide under application is considered a compound with high dusting potential, which may result in a critical exposure of users by inhalation, affecting the respiratory system.

The authorised use of zinc oxide as a feed additive does not pose a direct concern for the agricultural soil compartment. However, there is a potential environmental concern related to groundwater, drainage and the run-off of zinc to surface water. Acid sandy soils are most vulnerable to these processes. In order to draw a final conclusion, some further refinement to the assessment of zinc-based feed additives in livestock needs to be considered, for which additional data would be required. The use of zinc-containing additives in aquaculture up to maximum authorised zinc level in feeds is not expected to pose an appreciable risk to the environment.

Zinc oxide is efficacious in meeting animal zinc requirements.

[14] Regulation (EC) No 183/2005 of the European Parliament and of the Council of 12 January 2005 laying down requirements for feed hygiene. OJ L 35, 8.2.2005, p. 1.

RECOMMENDATIONS

The minimum zinc content of zinc oxide should be specified to 72 % (minimum purity 90 % zinc oxide).

The proposal of the applicant in Table 1 "Can only be used through a premixture" is not considered necessary.

GENERAL REMARKS

Current knowledge on the zinc requirements of animals, and the variation in bioavailability of zinc from different sources, indicate the potential to considerably reduce the current maximum content for dietary zinc without affecting animal health and welfare and productivity of animal husbandry. The reduction of the maximum content for zinc would decrease the zinc load in the environment. The simultaneous use of phytases opens further possibilities for the reduction of dietary zinc in animal nutrition. A new assessment of the zinc requirements/allowances of animals would provide the basis to react if a need for action will arise from another relevant field like ecology.

The FEEDAP Panel notes that problems of high zinc concentrations in groundwater, drainflow and runoff, once established, would be difficult to remediate; it is recommended to assess soil sensitivity before setting policies on manure application.

DOCUMENTATION PROVIDED TO EFSA

1. Dossier Zinc oxide for all species. July 2010. Submitted by Grillo Zinkoxid GmbH/EMFEMA.
2. Dossier Zinc oxide for all species. Supplementary information. March 2012. Submitted by Grillo Zinkoxid GmbH/EMFEMA.
3. Evaluation report of the European Union Reference Laboratory for Feed Additives on the methods(s) of analysis for Zinc (E6).
4. Comments from Member States received through the ScienceNet.

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EFSA Panel on Additives and Products or Substances used in Animal Feed (FEEDAP), 2009a. Safety of Mintrex®Zn (Zinc chelate of hydroxy analogue of methionine) as feed additive for chickens for fattening. The EFSA Journal 1042, 1-8.

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APPENDICES

APPENDIX A

Executive Summary of the Evaluation Report of the European Union Reference Laboratory for Feed Additives on the Method(s) of Analysis for Zinc (E6)[1]

In the current application authorisation is sought under articles 4(1) and 10(2) for *zinc acetate dihydrate*[2], *zinc chloride anhydrous*[1], *zinc oxide*[1, 5], *zinc sulphate heptahydrate*[1], *zinc sulphate monohydrate*[1, 2, 3], *zinc chelate of amino acids hydrate*[1, 4] *and zinc chelate of glycine hydrate*[1] under the category/functional group 3(b) of "nutritional additives"/"compounds of trace elements", according to the classification system of Annex I of Regulation (EC) No 1831/2003.

According to the Applicants: - *zinc acetate dihydrate* is white solid with a minimum content of 29.6 % total zinc; - *zinc chloride anhydrous* is white to slightly coloured solid with a minimum content of 46 % total zinc; - *zinc oxide* is white to dark green or beige brownish solid with a minimum content of 72 % total zinc; - *zinc sulphate heptahydrate* is a white solid with a minimum content of 22 % total zinc; - *zinc sulphate monohydrate* is a white to cream coloured solid with a minimum content of 34 % total zinc; - *zinc chelate of amino acid hydrate* is beige to dark tanned solid with a minimum content of 10 % total zinc; and - *zinc chelate of glycine hydrate* is white to cream coloured solid with a minimum content of 24 % total zinc. Specifically, authorisation is sought for the use of these *feed additives* for all categories and species.

For the identification and quantification of the inorganic zinc compounds (i.e. *zinc acetate dihydrate, zinc chloride anhydrous, zinc oxide, zinc sulphate heptahydrate and zinc sulphate monohydrate*) in the *feed additive*, the EURL recommends for official control the relevant European Pharmacopoeia Monograph (1482, 0110, 0252, 0111 and 2159) methods, based on complexometric titration with 0.1 M sodium EDTA using xylenol orange triturate as indicator.

For the quantification of "amino" content in the amino zinc chelates (i.e. z*inc chelate of glycine hydrate* and *zinc chelate amino acids hydrate*), the Applicant proposed - upon request from the EURL - the Community method based on High Performance Liquid Chromatography (HPLC) combined with post-column derivatisation using ninhydrin as derivatisation agent and photometric detection at 570 nm. The EURL considers the Community method suitable for the characterisation of the amino compounds in the frame of official control.

For the *determination* of total zinc in all the *feed additives*, *premixtures* and *feedingstuffs* the Applicant submitted the CEN method (EN 15510), based on inductively coupled plasma atomic emission spectroscopy (ICP-AES). The following performance characteristics were reported: - a relative standard deviation of *repeatability* (RSD_r) ranging from 1.7 to 8.8 %; - a relative standard deviation for *reproducibility* (RSD_R) ranging from 5.0 to 19 %; and - a limit of quantification (LOQ) of 3 mg/kg. Furthermore, the Applicant identified an alternative CEN ring-trial validated method (CEN/TS 15621) based on ICP-AES after pressure digestion, for the determination of total zinc in the *feed additive*, *premixtures* and *feedingstuffs*. The following performance characteristics were reported for a feed for pigs, and for sheep, a rock phosphate, a mineral premix and a mineral mix, where the total zinc content ranged from 26.6 to 3618 mg/kg: - RSD_r ranging from 1.5 to 5.4 %; - RSD_R ranging from 2.7 to 22 %; and - LOQ = 1 mg/kg *feedingstuffs*. Finally, the Applicant suggested the Community method for the determination of total zinc in *feedingstuffs*, with limited method performance characteristics provided. However, the UK Food Standards Agency organised a comparative trial based on the above mentioned Community method and reported precisions (RSD_r and RSD_R) for *feedingstuffs* ranging from 1.0 to 9.5 %.

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[1] The full report is available on the EURL website: http://irmm.jrc.ec.europa.eu/SiteCollectionDocuments/FinRep-SANCO-Zinc.pdf

[2] FAD-2010-0142; [2] FAD-2010-0228; [3] FAD-2010-0059; [4] FAD-2010-0063; [5]FAD-2010-0072

Based on these acceptable method performance characteristics the EURL recommends for official control the ICP-AES CEN methods (EN 15510 and CEN/TS 15621) to determine total zinc content by in the *feed additive* and *premixtures.* As for the determination of total zinc content in *feedingstuffs*, the EURL recommends for official control the Community method based on AAS together with the above mentioned ICP-AES CEN methods.

For the quantification of total zinc in *water* the Applicant[2] submitted the ring trial validated method EN ISO 11885, based on ICP-AES. The following performance characteristics are reported: - RSD_r ranging from 1.5 to 2.4 %; - RSD_R ranging from 4.9 to 5.9 %; and LOQ = 1 µg/L. Based on these acceptable method performance characteristics the EURL recommends for official control the CEN methods (EN ISO 11885) to quantify total zinc content by ICP-AES in the *water.*

Further testing or validation of the methods to be performed through the consortium of National Reference Laboratories as specified by Article 10 (Commission Regulation (EC) No 378/2005) is not considered necessary.

APPENDIX B

Update on the biological role and toxicity of zinc

Zinc is a trace element that is essential to all known organisms, and it is the second most abundant trace element, after iron, in most vertebrates. Zinc is required for a variety of basic biological processes, including metabolism of proteins, nucleic acids, carbohydrates and lipids, and it is also involved in more complex processes, such as the immune response, neurotransmission and cell signalling (Coleman, 1992; Beyersmann, 2002; Murakami and Hirano, 2008). It has been estimated that there are approximately 3 000 zinc-containing proteins in humans (Passerini et al., 2007). Almost all of the zinc in cells is bound to proteins, peptides and amino acids, but there is a minute fluctuating pool of labile cytosolic Zn^{2+}, which is involved in cell signalling pathways (Murakami and Hirano, 2008; Haase and Rink, 2009; Hogstrand et al., 2009). One of the mechanisms by which Zn^{2+} transduces intracellular signals is by inhibition of protein tyrosine phosphatases; for example, this is believed to be the molecular mechanism behind its insulin-mimetic effect (Haase and Maret, 2003; Miranda and Dey, 2004; Wong et al., 2006). Uptake of zinc, as well as its compartmentalisation between tissues and within cells, is managed principally by two large and biologically ubiquitous families of zinc transporters, the ZnT (SLC30A) family and the ZIP (SLC39A) family, which between them have 24 paralogues in most mammals (Feeney et al., 2005). The distinct distribution and activities of these transporters determine the distribution of zinc within cells and animals. However, cellular zinc influx may also occur via various Ca^{2+} channels and probably through some amino acid transporters.

Dietary zinc has low toxicity to vertebrates (Clearwater et al., 2002; van Paemel et al., 2010). Some of the most sensitive effects of zinc toxicity are impairment of copper and iron uptake with knock-on effects on systems depending on these metals (Eid and Ghonim, 1994; Balesaria et al., 2010). There are also effects on lipid metabolism and the immune system as zinc is a natural regulator of processes involved in these functions. Water-breathing organisms are sensitive to waterborne zinc, with acute toxicity concentrations typically being higher than those for metals such as silver, cadmium and copper but lower than those for manganese and nickel (McDonald and Wood, 1993). The relatively high risk of zinc toxicity to aquatic life has led to its inclusion as a “priority pollutant” by the US Environmental Protection Agency (USEPA, 2002).

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APPENDIX C

List of Risk Assessment Reports on zinc and zinc compounds

Besides the reports cited in the Background section, risk assessments from other EU bodies and Institutions have been carried out. Bodar et al. (2005) summarised the process and facts of the EU risk assessment of zinc and zinc compounds.

1. EU Risk Assessment Reports (RARs)

Zinc metal (CAS No. 7440-66-6). Available online at:
http://publications.jrc.ec.europa.eu/repository/bitstream/111111111/15064/1/lbna24587enn.pdf

Zinc oxide (CAS No. 1314-13-2). Available online at:
http://esis.jrc.ec.europa.eu/doc/existing-chemicals/risk_assessment/REPORT/zincoxidereport073.pdf

Zinc chloride (CAS No. 7646-85-7). Available online at:
http://esis.jrc.ec.europa.eu/doc/existing-chemicals/risk_assessment/SUMMARY/zincchlorideENVsum075.pdf

Zinc distearate (CAS No 557-05-1/91051-01-3). Available online at:
http://esis.jrc.ec.europa.eu/doc/existing-chemicals/risk_assessment/REPORT/zincdistearatereport074.pdf

Zinc sulphate (CAS No. 7733-02-0). Available online at:
http://esis.jrc.ec.europa.eu/doc/existing-chemicals/risk_assessment/SUMMARY/zincsulphateENVsum076.pdf

Trizinc bis(orthophosphate) (CAS No. 7779-90-0). Available online at :
http://esis.jrc.ec.europa.eu/doc/existing-chemicals/risk_assessment/REPORT/zincphosphatereport077.pdf

2. EC Health and Consumers Scientific Committees Opinions

The Scientific Committee on Health and Environmental Risk (SCHER) opinion on the RARs on Zn. (http://ec.europa.eu/health/ph_risk/committees/04_scher/docs/scher_o_069.pdf)

The Scientific Committee on Cosmetic Products and Non-Food Products intended for Consumers. Opinion concerning Zinc oxide. http://ec.europa.eu/health/ph_risk/committees/sccp/documents/out222_en.pdf

3. EFSA-ANS Panel Opinions

Chromium picolinate, zinc picolinate and zinc picolinate dihydrate added for nutritional purposes in food supplements (http://www.efsa.europa.eu/en/efsajournal/pub/1113.htm)

Magnesium aspartate, potassium aspartate, magnesium potassium aspartate, calcium aspartate, zinc aspartate, and copper aspartate as sources for magnesium, potassium, calcium, zinc, and copper added for nutritional purposes to food supplements - Scientific Panel on Food Additives and Nutrient Sources added to food (http://www.efsa.europa.eu/en/efsajournal/pub/883.htm)

Calcium L-methionate, magnesium L-methionate and zinc mono-L-methionine sulphate added for nutritional purposes to food supplements - Scientific Opinion of the Panel on Food Additives and Nutrient Sources added to Food (http://www.efsa.europa.eu/en/efsajournal/pub/924.htm)

Calcium ascorbate, magnesium ascorbate and zinc ascorbate added for nutritional purposes in food supplements http://www.efsa.europa.eu/en/efsajournal/pub/994.htm

4. EFSA-AFC Panel Opinions

Opinion of the Scientific Panel on food additives, flavourings, processing aids and materials in contact with food (AFC) related to Calcium, Magnesium and Zinc Malate added for nutritional purposes to food supplements as sources for Calcium, Magnesium and Zinc and to Calcium Malate added for nutritional purposes to foods for particular nutritional uses and foods intended for the general population as source for Calcium (http://www.efsa.europa.eu/en/efsajournal/pub/391a.htm)

Opinion of the Scientific Panel on food additives, flavourings, processing aids and materials in contact with food (AFC) related to Calcium, iron, magnesium, potassium and zinc L-pidolate as sources for calcium, iron, magnesium, potassium and zinc added for nutritional purposes to food supplements and to foods intended for particular nutritional uses (http://www.efsa.europa.eu/en/efsajournal/pub/495.htm)

Magnesium L-lysinate, calcium L- lysinate, zinc L- lysinate as sources for magnesium, calcium and zinc added for nutritional purposes in food supplements - Scientific Opinion of the Panel on Food Additives, Flavourings, Processing Aids and Materials in Contact with Food (http://www.efsa.europa.eu/en/efsajournal/pub/761.htm)

Opinion on certain bisglycinates as sources of copper, zinc, calcium, magnesium and glycinate nicotinate as source of chromium in foods intended for the general population (including food supplements) and foods for particular nutritional uses - Scientific Opinion of the Scientific Panel on Food Additives, Flavourings, Processing Aids and Materials in Contact with Food (http://www.efsa.europa.eu/en/efsajournal/pub/718.htm)

5. EFSA-NDA Panel Opinions

Scientific Opinion on the substantiation of health claims related to zinc and maintenance of normal skin (ID 293), DNA synthesis and cell division (ID 293), contribution to normal protein synthesis (ID 293, 4293), maintenance of normal serum testosterone concentrations (ID 301), “normal growth” (ID 303), reduction of tiredness and fatigue (ID 304), contribution to normal carbohydrate metabolism (ID 382), maintenance of normal hair (ID 412), maintenance of normal nails (ID 412) and contribution to normal macronutrient metabolism (ID 2890) pursuant to Article 13(1) of Regulation (EC) No 1924/2006 (http://www.efsa.europa.eu/en/efsajournal/pub/1819.htm)

Scientific Opinion on the substantiation of health claims related to zinc and function of the immune system (ID 291, 1757), DNA synthesis and cell division (ID 292, 1759), protection of DNA, proteins and lipids from oxidative damage (ID 294, 1758), maintenance of bone (ID 295, 1756), cognitive function (ID 296), fertility and reproduction (ID 297, 300), reproductive development (ID 298), muscle function (ID 299), metabolism of fatty acids (ID 302), maintenance of joints (ID 305), function of the heart and blood vessels (ID 306), prostate function (ID 307), thyroid function (ID 308), acid-base metabolism (ID 360), vitamin A metabolism (ID 361) and maintenance of vision (ID 361) pursuant to Article 13(1) of Regulation (EC) No 1924/2006 (http://www.efsa.europa.eu/en/efsajournal/pub/1229.htm)

Scientific Opinion on the substantiation of a health claim related to zinc and “the prevention of bad breath by neutralising of volatile sulphur compounds in the mouth and oral cavity” pursuant to Article 13(5) of Regulation (EC) No 1924/2006 (http://www.efsa.europa.eu/en/efsajournal/pub/2169.htm)

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APPENDIX D

List of authorisations of zinc other than feed additive

The following zinc compounds are authorised for use in food (Regulation (EC) No 1170/2009):[1] zinc acetate, zinc chloride, zinc oxide, zinc sulphate, zinc bisglycinate, zinc L-Lysinate (which may be used in the manufacture of food supplements); zinc acetate, zinc chloride, zinc oxide, zinc sulphate, zinc bisglycinate, which may be added to food. Zinc acetate (E-650) is authorised as food additive for its use in chewing gum at the maximum level of 1000 mg/kg (European Parliament and Council Directive No 95/2/EC).[2]

The following zinc compounds can be used for the manufacturing of dietetic foods (Commission Regulation (EC) No 953/2009):[3] zinc acetate, zinc chloride, zinc citrate, zinc gluconate, zinc lactate, zinc oxide, zinc carbonate, zinc sulphate and zinc bisglycinate.

The following zinc compounds can be used for the manufacturing of processed cereal-based foods and baby foods for infants and young children (Commission Directive 2006/125/EC):[4] zinc, zinc acetate, zinc citrate, zinc lactate, zinc sulphate, zinc oxide and zinc gluconate.

The following zinc compounds are listed in Table 1 of the Annex of Regulation 37/2010[5] as *Allowed substances, no MRL required*: zinc acetate, zinc aspartate, zinc choride, zinc gluconate, zinc oleate, zinc oxide, zinc stearate, zinc sulphate.

The following zinc compound is listed in Annex of Commission Implementing Regulation (EU) No 540/2011[6] as “Active substances approved for use in plant protection products”: Trizinc diphosphide (Zinc phosphide).

The following type of fertilizers for zinc as *Fertilisers containing only one micro-nutrient* are listed in Annex I of Regulation (EC) No 2003/2003 of the European Parliament and of the Council:[7] (a) zinc salt (chemically obtained product and having as its essential ingredient a mineral salt of zinc), (b) zinc chelate (water-soluble product obtained by combining zinc chemically with a chelating agent), (c) zinc oxide (chemically obtained product and having as its essential ingredient zinc oxide), (d) zinc-based fertiliser (product obtained by mixing types ‘a’ and ‘c’), zinc-based fertiliser solution (product obtained by dissolving types ‘a’ and/or one of type ‘b’ in water).

The following zinc compounds can be used for cosmetic purposes (Regulation (EC) No 1223/2009 of the European Parliament and of the Council):[8] zinc acetate, zinc chloride, zinc gluconate, zinc glutamate, zinc phenolsulfonate, zinc oxide, zinc stearate, zinc pyrithione, zinc peroxide.

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1 Commission Regulation (EC) No 1170/2009 of 30 November 2009 amending Directive 2002/46/EC of the European Parliament and of Council and Regulation (EC) No 1925/2006 of the European Parliament and of the Council as regards the lists of vitamin and minerals and their forms that can be added to foods, including food supplements. OJ L 314, 1.12.2009, p. 36.

2 European Parliament and Council Directive No 95/2/EC of 20 February 1995 on food additives other than colours and sweeteners. OJ L 61, 18.3.1995, p. 1.

3 Commission Regulation (EC) No 953/2009 of 13 October 2009 on substances that may be added for specific nutritional purposes in foods for particular nutritional uses. OJ L 269, 14.10.2009, p. 9.

4 Commission Directive 2006/125/EC of 5 December 2006 on processed cereal-based foods and baby foods for infants and young children. OJ L 339, 6.12.2006, p. 16.

5 Commission Regulation (EU) No 37/2010 of 22 December 2009 on pharmacologically active substances and their classification regarding maximum residue limits in foodstuffs of animal origin. OJ L 15, 20.1.2010, p. 1.

6 Commission Implementing Regulation (EU) No 540/2011 of 25 May 2011 implementing Regulation (EC) No 1107/2009 of the European Parliament and of the Council as regards the list of approved active substances. OJ L 153, 11.6.2011, p. 1.

7 Regulation (EC) No 2003/2003 of the European Parliament and of the Council of 13 October 2003 relating to fertilisers. OJ L 304, 21.11.2003, p. 1.

8 Regulation (EC) No 1223/2009 of the European Parliament and of the Council of 30 November 2009 on cosmetic products. OJ L 342, 22.12.2009, p. 59.

According to the Annex to Regulation (EC) No 432/2012[9] the following health claims can be made only for food which is at least a source of zinc as referred to in the claim SOURCE OF [NAME OF VITAMIN/S] AND/OR [NAME OF MINERAL/S] as listed in the Annex to Regulation (EC) No 1924/2006:[10] zinc contributes to normal acid-base metabolism, zinc contributes to normal carbohydrate metabolism, zinc contributes to normal cognitive function, zinc contributes to normal DNA synthesis, zinc contributes to normal fertility and reproduction, zinc contributes to normal to macronutrient metabolism, zinc contributes to normal metabolism of fatty acids, zinc contributes to normal metabolism of vitamin A, zinc contributes to normal protein synthesis, zinc contributes to the maintenance of normal bones, zinc contributes to the maintenance of normal hair, zinc contributes to the maintenance of normal nails, zinc contributes to the maintenance of normal skin, zinc contributes to the maintenance of normal testosterone levels on the blood, zinc contributes to the maintenance of normal vision, zinc contributes to the normal function of the immune system, zinc contributes to the protection of cells from oxidative stress, zinc has a role in the process of cell division.

[9] Commission Regulation (EC) No 432/2012 of 16 May 2012 establishing a list of permitted health claims made on foods, other than those referring to the reduction of disease risk and to children's development and health. OJ L 136, 25.05.2012, p.1.

[10] Regulation (EC) No 1924/2006 of the European Parliament and of the council of 20 December 2006 on nutrition and health claims made for food. OJ L 404, 30.12.2006, p.9.

ABBREVIATIONS

ATSDR	Agency for Toxic Substances and Disease Registry
As	arsenic
CAS	Chemical Abstracts Service
Cd	Cadmium
EC	European Commission
ECHA	European Chemicals Agency
EFSA	European Food Safety Authority
EMFEMA	European Manufacturers of major trace and specific Feed Mineral Materials
EsKiMo	Ernährungsstudie als KIGGS-Modul
EU	European Union
EURL	European Union Reference Laboratory
FEEDAP	Panel on Additives and Products or Substances used in Animal Feed
FOCUS	Forum for the Coordination of Pesticide Fate Models and Their Use
Hg	mercury
MRL	maximum residue limit
NRC	National Research Council
Pb	lead
PCBs	Polychlorinated biphenyls
PCDDs	Polychlorinated dibenzo-*para*-dioxins
PCDFs	Polychlorinated dibenzofurans
PECs	Predicted Environmental Concentrations
PNECs	Predicted No Effect Concentrations
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
SCAN	Scientific Committee on Animal Nutrition
SCF	Scientific Committee on Food
TEQ	Toxic Equivalent Factor
UL	Tolerable Upper Intake Level
WHO	World Health Organisation
Zn	zinc