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A model for risk-based monitoring of contaminants in feed ingredients

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ABSTRACT

A qualitative spreadsheet model has been developed for ranking feed ingredients on the basis of the potential risk of exceeding existing guidance or maximum levels in the EU for a certain contaminant, and the potential consequence of the presence of this contaminant on the health of animals and/or humans. The approach was based on the general concept of risk, being frequency times consequences of presence of the contaminant. Contamination of compound feeds due to presence of the contaminant in feed ingredients was estimated, per animal category, by: annual volumes of feed ingredients used for feed production, stratified per country of origin; the portion of each ingredient in compound feed formulations used for various animal categories; and the potential contamination of an ingredient per country of origin. The consequences of the contamination were accounted for by two consequence factors, both estimated per animal category: one for the potential impact of the contaminant on the health of the target animal, and one for the impact on human health, related to the possible formation of residues in animal derived food products.

The use of the model was demonstrated by its application to the presence of dioxins and dl-PCBs in compound feed for farm animals produced in the Netherlands in 2013 and 2014. Model results include the relative contribution, based on relative ranking scores, of each feed ingredient to the chance of exceeding limits and potential consequences on animal and human health. Feed ingredients ranking highest were palm oil, other fats and oils, dried products like bakery products, sunflower expeller/extracted, maize, and fish meal.

The model can be used by risk managers in feed industry and by governmental bodies for supporting decision making on the optimal allocation of resources for control of ingredients for compound feed production for presence of contaminants.

1. Introduction

Compound feed for farm animals can be contaminated by chemical substances – such as dioxins, heavy metals and mycotoxins – which may affect animal health and productivity, and also may be hazardous to human health in case the contaminant is transferred to animal derived food products. The presence of such toxic substances (contaminants) in animal feed is dependent on their presence in the ingredients used in the feed formulation and the inclusion rate of each ingredient, as well as feed production processes. Besides roughage, animal diets are largely based on compound feeds from cereal grains and co-products from food industry, e.g. soybean meal, bakery products and sugar beet pulp. Market, environmental and technological conditions – such as availability of feed materials, their country or region of origin, local weather conditions, and technological processes – show transient and structural changes over time. For example, in the last decade the use of cereal grains in animal diets in Europe, imported from Eastern Europe increased at the expense of imported tapioca meal from South East Asia. More recently, an increasing volume of rapeseed meal and dried distillers grain with solubles (DDGS) became available for inclusion in animal feed, resulting from the drastic increase in biofuel production. In addition, the increasing demand for agricultural raw materials for biofuel production and the rapidly growing livestock sector in developing countries cause a shift in the countries of origin from which feed ingredients are sourced and in global trade of feed materials. All such changes have a potential influence on the presence of chemical hazards in feed

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production and, consequently, on feed and food safety.

The aim of the current study was to develop a model for estimating the relative contribution of individual feed ingredients, used at the national level, in compound feed to the potential impact on animal and human health, related to the presence of a given contaminant in the feed ingredients. In principle the model aims at identifying those ingredients that may exceed maximum or guidance values, or may result in exceedance of maximum levels in animal derived food products.

2. Material and methods

2.1. General description of the model

A spreadsheet model was developed to estimate the relative contribution of feed ingredients of compound feeds for farm animals to the potential impact on animal health (including performance) and on human health related to the presence of a particular contaminant in feed ingredients. The impact score, and the relative ranking score per ingredient were calculated, using the HACCP (Hazard Analysis Critical Control Point) definition of risk, being presence (frequency/concentrations) of the contaminant times its consequences. Calculation of presence of the contaminant was based on: total volume of each feed ingredient used for compound feed production stratified to the country of origin, distribution of ingredients over compound feeds used for different animal categories, and potential contamination of ingredients with the specific contaminant, also related to the country of origin. Consequences for animals were expressed by the potential impact (in classes) of the contaminant on animal health, estimated per animal category. Consequences for humans were expressed by the potential impact (in classes) of the contaminant on human health, when consuming foods derived from animals, estimated per animal category. For this, exceedance of maximum or guidance values was used as the basis, since these values were set to protect the health of animals and humans. In practice, however, maximum levels for feed may aim primarily at avoiding too high levels in animal derived food products, rather than at protecting animals. This is e.g. the case for dioxins and aflatoxins, whereas for certain mycotoxins (e.g. deoxynivalenol) guidance values were set for feed ingredients, to avoid adverse effects in animals. Therefore, the model not only incorporates the possible non-compliance of feed ingredients to certain limits set for the presence of the contaminant, but also considers potential impacts to animals in the absence of specific animal-directed limits. Model results provide relative ranking scores per ingredient, which can be used to rank, feed ingredients based on their contribution to the potential impact on the health of animals and/or human (after consumption of food of animal origin), due to the contaminant of interest.

The impact score for a potential toxic contaminant in a given feed ingredient is calculated according to the general equations:

$$S_{all} = S_{human} + S_{animal}$$

Where,

$$S_{human} = \Sigma\ (^{10}\log a \times b \times c \times\ \times d \times e_{human})$$
$$S_{animal} = \Sigma\ (^{10}\log a \times b \times c \times d \times e_{animal})$$

With:

S_{all} = Overall score for impact to the health of animals (S_{animal}) and humans (S_{human}), taking into account the presence of the specific contaminant in specific feed ingredients from specific country of origins, for specific animal categories;

a = Total usage of the ingredient (continuous, kton);
b = Portion of feed ingredient per animal category (continuous, 0–1);
c = Portion of feed ingredient from a specific country of origin (continuous, 0–1);
d = Contamination factor representing the probability and level of occurrence of the contaminant in the ingredient in each country of origin (classes, values of 0.01 (low), 0.1 (medium), 1 (high));
e = Consequence factor of the contaminant per animal category for impact on health of animals (e_{animal}) or human (e_{human}) (classes, values of 0.01 (low), 0.1 (medium), or 1 (high));

Factor a represents the total usage of each of the feed ingredients. This volume of ingredients is expressed on a ^{10}log scale to avoid an overruling influence of raw materials commonly used in compound feed production in large volumes (e.g. maize, wheat and soybean meal). Factor b represents the relative distribution of a given ingredient over feeds used for different animal categories (e.g. broilers, laying hens, growing pigs). It is calculated based on the volume and composition of diets (feed formulation) assumed representative for the involved animal categories. Factor c represents the relative proportion of the ingredient imported from different countries.

The origin related contamination factor d represents the likelihood of relatively high levels of the particular contaminant in feed ingredients from a specific country, with three different levels being 0.01, 0.1 and 1 for each ingredient. This factor is assessed by expert judgement using literature and historical data, e.g. on analytical results for the contaminant of interest from (national) monitoring programmes, RASFF (Rapid Alert System for Food and Feed) notifications, and incident data. Circumstances during production and processing may also be considered but also the lack of knowledge of the production process (worst case assumption).

For the consequence of the contaminant (factor e), two factors are considered for each animal category; one for potential impact or effects on animal health and productivity (e_{animal}) and one for potential impact or effects on health of humans consuming animal derived products (e_{human}). Both consequence factors are assigned one out of three values, being 0.01, 0.1, and 1, i.e. low, medium and high, by experts, considering available data and scientific literature on residue transfer and accumulation, and toxic effects of the contaminant on animal and human. The consequence factor for animal health (e_{animal}) allows to take into account that animal species differ in sensitivity to potentially toxic components. For example, pigs generally are more sensitive to the mycotoxin deoxynivalenol (DON) than poultry and ruminants, hence, the value of the consequence factor e_{animal} for this mycotoxin would be higher for pigs than for other species (which is also reflected in the guidance values set by the EC). The consequence factor for humans (e_{human}) covers potential accumulation of residues of the contaminant in animal derived foods, and the potential impact of the contaminant on human health when consuming contaminated animal derived foods.

In the model, the total impact score (S) for the contaminant of interest in a given feed ingredient is determined for all animal categories and all countries of origin, using the cumulative results of Equation. Subsequently, the relative contribution of each ingredient to the total impact score of a contaminant is calculated and ingredients are ranked on the basis of their contribution.

2.2. Application of the model to dioxins and dl-PCBs

The model was applied for ranking feed ingredients of compound feed used in the Netherlands in 2013 and 2014, as regard