UDC 632.8: 631.14

EUROPEAN FOOD SAFETY AUTHORITY: EXPERINCE OBTAINED IN ASSESSING EXPOSURE OF FARM AND ODMESTIC ANIMALS TO CHEMICAL IMPURITIES IN CEREAL CROPS AND FINISHED FODDER BLENDS (ON THE EXAMPLE OF DEOXYNIVALENOL)

Fanny Héraud[1], N.V. Nikiforova[2]

[1]European Food Safety Authority, Italy, 43126, Parma,Via Carlo Magno 1A
[2] Federal Scientific Center for Medical and Preventive Health Risk Management Technologies, 82, Monastyrskaya str., Perm 614045 Russia

The article presents the research results obtained within the framework of international cooperation aimed at studying approaches to health risk assessment for population and domestic animals, the risk being caused by consuming food stuffs containing deoxynivalenol (DON). It also contains the data on contamination levels for cereal crops used as fodder for animals, deoxynivalenol and its metabolites being in the focus of attention. We highlight the approach to acute and chronic exposure of farm and domestic animals to chemical impurities in cereal crops and finished fodder blends. As a results of chronic exposure assessment we detected that DON intake doze which penetrates animal bodies with cereal crops and finished fodder varies within the range 3.9-43.5 µg/kg a day. Broiler chicken and broiler ducks receive the highest doze both in each separate fodder intake and in constant fodder intake. And we can expect to see most probable negative effects (lower body weight, toxicosis etc) caused by DON contained in fodder in poultry, farm pigs, and broiler ducks.

Key words: *deoxynivalenol, fodder, cereal crops, exposure, domestic animals*

European union guidelines and regulations fix the obligation to assess products safety as per risk criteria [4,7,10]. And here in the EU countries greater attention is paid to safety issues not only in respect of consumption end products but also products safety at any stage in food chain. Experts in food safety and regional trade from the UN Food and Agricultural Organization visited a round-table discussion held in Moscow and dedicated to promotion of European-Asian trade integration aimed at agriculture stability and food safety. They outlined the importance of integrated approach to products safety assessment including safety and quality of fodder for animals and consumption practices at the other end of food chain [1].

Experts from European Food Safety Authority as an organization authorized to conduct such work as per clause 23 and 33 EU Regulations No. 178/20025 systematically examine scientific research results concerning contaminations contained in fodder, such as nitrates, poly-chlorinated biphenyls, mycotoxins etc. A number of contaminations require specialized data collection; the data are obtained in the course of state surveillance and/or monitoring. All the information is accumulated in the united database where it is systematized and analyzed by EFSA experts. This database is constantly replenished and updated so that data continuity is provided. It allows EFSA to get access to all information necessary to process urgent enquiries, to make operative decisions when contaminations are detected etc.

When organizing scientific research, EFSA tries to tackle most vital problems outlined by the EU government. Thus, there are tasks aimed at examining exposure to heavy metals, furan, and acrylamide, contained in food stuffs; the data on exposure of farm animals to nitrates,

Fanny Héraud – Officer (tel: +39 0521 036111)
Nadezhda V. Nikiforova – junior scientific officer (e-mail:kriulina@fcrisk.ru; tel.: +7(342)237–18– 04)

poly-chlorinated biphenyls and some mycotoxins, are being accumulated.Experience gained by our foreign colleagues is of great value for the Russian Federation and the Customs Union countries and it should be examined in details and enriched as well [2]. Within the frameworks of skill-sharing in EFSA and in full conformity with all the EU requirements and standards EFSA experts and their Russian counterparts accomplished the research dedicated to assessment of exposure to deoxynivalenol consumed by domestic animals together with feed crops.

Deoxynivalenol is a mycotoxin from Trichotecinum class. It is a product of microscopic fungus from *Fusarium* genus *(Fusarium graminearum, Fuculmorum, F.roseum* and others) which are widely spread in European temperate latitudes. Its chemical structure is shown in Figure 1 (figure 1). This substance is chemically resistant to treatment, including various heat treatments which are used when agricultural raw materials are being processed [8].

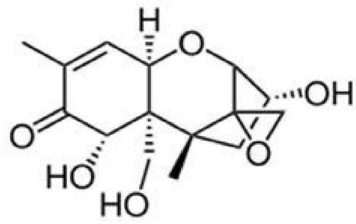

Figure. 1 DON chemical structure

Mycotoxin is primarily found in cereal crops, such as wheat, barley, oats, rye, and corn; it can be more rarely found in rice and sorghum. Here grains can get contaminated both in a field and during storage [3]. DON toxic effect is quite similar to those of other Trichotecinum and it reveals itself in the process of protein synthesis inhibition (Shepard, 2011) [14]. Fodder for domestic animals made of wheat contaminated with DON can cause acute toxicosis, poorer functioning of immune system, kidneys function disorders, as well as lead to lower body weight of an animal, and this effect in its turn results in lower quantities of obtained meat and decrease in economic benefits of meat production. Several cases of intoxication caused by DON were detected in Asia [9]. A data collection campaign carried out in 2001 and dedicated to accumulating data on *Fusarium* toxins level in food consumed by the EU countries population gave the opportunity to obtain DON analysis results from 11 thousand samples taken in 12 EU countries. DON was detected in 57% samples. It was revealed that wheat and wheat products (for example, bread, macaroni and others) were the main source of DON exposure for consumers [12]. There was a task set for EFSA; the task was to obtain more precise data, to make out a systematizing repost containing actual assessment of contamination levels for fodder and food stuffs as well as assessment of acute and chronic DON impact on people and animals. All the interested parties and EU member-countries combined their efforts to achieve the set objectives and to accomplish the task in full conformity with the EU Commission Statement No. 1881/2006 and EU Commission Recommendations 2006/576. The EU member states undertook to send all the research results to EFSA.

Data and methods. To assess acute and chronic exposure to DON the researchers used literature data dedicated to cereal crops types, which were most frequently contaminated with Fusarium class fungus; to animals classes which were most susceptible to DON impact; to animals nutrition structure. The results of the researches accomplished in full conformity with EU Commission Regulations 401/2066 and 882/2004 only in the laboratories accredited in accordance with established procedures were used as basic information [5,11]. The information was provided in unified format which was obligatory for all the interested parties. Preliminary data processing for the data accumulated in Data Collection Framework system was automated. Any information duplication was excluded. In such cases when several measurements were performed with the use of various analytical methods the further analysis included the results obtained via the most sensitive technique. Qualitative composition, humidity, contamination level, and detection limit, were verified for each sample. The data were classified in details in accordance with the EU product range classification.

To calculate DON intake doze for feed crops and finished fodder blends, we used the EU database which contained monitoring data on priority cereal crops contamination with DON over 2007-2012 as well as data on animals consumption of various cereal crops and finished fodder blends [6].

This is the general formula to calculate chronic exposure (1):

$$Exp = \frac{\sum_{i=1}^{N} (C_i * M_i)}{BW} \text{, where} \quad (1)$$

Exp is value of exposure to contaminant, (μg/kg of body weight/day);
Ci is contaminant content in i-product, μg/kg;
Mi is i-product consumption, kg/day;
BW is an animal body weight, kg;
N is a total number of products, included into research.

To calculate DON intake doze and to assess exposure we applied 3 scenarios; the first scenario meant DON concentrations in cereal crops and finished fodder blends were lower than detection limit or below qualitation and such concentrations were assigned with "0" value (LV or lower value). The second scenario meant that DON concentrations values amounted to half a value of detection limit or analytical method qualitation (AV or average value). In the 3rd scenario concentration values amounted to detection limit value or analytical method qualitation (UV or upper value).

Data on fodder and finished fodder blends consumption by animals and animals body weight used to assess exposure were taken from the EFSA reports dedicated to similar subjects [7,13].

To assess chronic exposure to DON consumed by animals with fodder we used average DON concentration; to assess acute exposure, 95-percentile of detected DON concentrations was applied.

Basic results. We analyzed 18,884 fodder and food stuffs samples and obtained more than 26,6 thousand results of DON and its derivatives quantitative determination (3 ADON, 15 ADON) in examined products and DON conjugate. The data were submitted by 21 EU member countries and Norway as per research results collected in 2007-2012.

We detected that DON was most frequently found in such cereal crops as wheat, barley, oats and others (table 1).

Table 1

DON content in unprocessed grain, μg/kg

Unprocessed grain type	Number of samples	Concentration (μg/kg)	
		Average value AV [LV,UV]*	95-percentile AV [LV,UV]*
Total	975	223.3 [204.1; 242.5]	920.8
Barley grain	198	133.2 [114.4; 152.1]	489
Corn grain	235	326.1 [292.5; 359.7]	1555.8
Oats grain	82	155.1 [136.8; 173.3]	640
Rye grain	130	57.5 [43.2; 71.7]	212 [212; 250]
Wheat grain	295	312.3 [301.6; 323.1]	1610
Other graine	35	66.6 [50.3; 82.9]	-

* Lower value (LV), average value (AV), upper value (AV) of exposure depending on one of three scenarios as given above. If the values were LV=AV=UV, only one value of calculated exposure was given in the table.

DON was quantitatively determined in 72.2% samples in "cereal crops, their products and by-products" category and in 95.2% barley samples. DON concentrations detected in corn and oats were significantly higher than DON concentrations detected in other cereal crops ($p<0.05$). Thus, average DON concentration in corn and oats amounted to 1041.9 and 1355.8 µg/kg correspondingly (95-percentile 4840-4489 µg/kg correspondingly). Average DON concentration in what amounted to 434.4 µg/kg (95-percentile 2481.1 µg/kg). Average dON concentrations in other cereal crops were detected within 176.1 - 195.3 µg/kg range (95-percentile 529.7-877 µg/kg).

DON was quantitatively detected in 78% samples of finished fodder blends for animals. The highest DON concentrations in finished fodder blends were detected in ones made for poultry in comparison with combined fodder for other animals ($p <0.05$). Average DON concentration in combined fodder for poultry was within the following range: from 413.9 µg/kg (starter for poultry) to 893.7 µg/kg (turkey fodder). 95-percentile was from 1734.4 µg/kg (goose fattening) to 2417.5 µg/kg (turkey fattening). Average DON concentrations in combined fodder for other animals were detected within the following range: from 136.5 µg/kg (fodder for animals, dogs and cats) to 453.3 µg/kg (sows in lactation period), 95-percentile was from 576.1 µg/kg (piglets) to 2207.7 µg/kg (fodder for domestic animals, dogs and cats). Higher DON concentrations in fodder for poultry can be caused by wheat in their composition.

As we stated in "data and methods" section, the data on daily fodder consumption were not collected specifically for this research. We used daily consumption scenarios which were described to a greater extent as standard (table 2 and 3).

Table 2

Body weight and daily fodder consumption by different animals

Animal type	Body weight (kg)	Daily fodder consumption (kg*dry substance weight /day)
Piglets	20	1.0
Fattening pigs	100	3.0
Sows in lactation period	200	6.0
Broiler chicken	2	0.12
Layers	2	0.12
Broiler turkeys	12	0.4
Broiler ducks	3	0.14
Salmon	2	0.04
Dogs	25	0.36
Cats	4	0.06

Table 3

An example of fodder blend composition for cats, dogs and fish nutrition

Salmon		Dogs and cats	
Fodder stuff	% content in fodder blend	Fodder stuff	% content in fodder blens
Fish flower	30.5	Wheat	15
Wheat corn	13.2	Barley	15
Dried soy (beans)	12.3	Corn	15
Corn gluten	11.5	Corn gluten	15
Fish and vegetable oils	31.9	Others*	40
Minerals and vitamins etc.	0.6	–	–

* Others means other fodder stuff, animal proteins mainly.

As we assessed chronic exposure we detected that DON intake doze with cereal crops and finished fodder varies from 3.9 to 43.5 µg/kg per day. Broiler chicken got the highest mycotoxin doze (43.5 µg/kg a day); the same goes for broiler ducks (43.5 µg/kg a day). DON doze consumed with fodder by pigs varied from 10.2 to 15.5 µg/kg a day (average value). As we assessed acute exposure we detected that again broiler chicken and broiler ducks got the highest mycotoxin doze (132.3 µg/kg and 137.9 µg/kg correspondingly) (table 4).

Table 4.

Assessment results for acute and chronic exposure to DON consumed with cereal crops and finished fodder blends by different animals (µg/kg a day, µg/kg).

Animal type	Chronic exposure, µg/kg a day AV [LV, UV]*	Acute exposure, µg/kg AV [LV, UV]*
Piglets	10.2 [7.8; 12.6]	
Fattening pigs	12.5 [11.9; 13]	44.6
Sows in lactation period	15.5 [14.8; 16.1]	-
Broiler chicken	43.5 [43; 44.1]	132.3
Layers	39.3 [38.2; 40.4]	137.9
Broiler ducks	33.9 [33.4; 34.3]	92.0
Salmon	3.9 [3.8; 4.1]	11.6 [11.6; 11.8]
Dogs	6.7 [6.5; 6.8]	27.1
Cats	6.9 [6.8; 7.1]	28.3

* Lower value (LV), average value (AV), upper value (AV) of exposure depending on one of three scenarios as given above. If the values were LV=AV=UV, only one value of calculated exposure was given in the table.

Pigs and poultry are the most sensitive to DON adverse effects. So, the most probable consequences of DON impact (lower body weight, toxicosis and other effects) when it is consumed by animals with fodder are to be expected in poultry, pigs and broiler ducks.

We should also note that the same scaling and detailed research was accomplished to assess exposure effects of DON and its derivatives on people. Data on such exposure were used as a basis for further health risk calculation and characteristics as well as for working out recommendations how to minimize it.

Primary conclusions:

- collecting, processing and analyzing data on DON and its derivatives can be considered as an example of qualitative and credible exposure assessment procedure used to assess consumer health risks caused by various products;
- integrating research results obtained in various countries but processed and assessed as per unified criteria and standards allows to create scientific foundation for tackling various tasks in products danger (safety) assessment;
- credibility of the obtained results is provided by scales of research where a lot of parties make their contribution into joint work as well as by unification of requirements to analytical research, accuracy in raw data selection for further analysis, transparency of exposure assessment procedure;
- published data on exposure assessment can be used as information basis for making management decisions in any complicated situations which require immediate response including those connected with detecting hazardous products;
- experience obtained by the EU in the sphere of collecting, accumulating and processing

data on hazardous contaminants in consumer food and non-food products can be applied in the Russian Federation and the Customs Union; it will help us to be more successful in solving tasks related to population health risk assessment, consumer safety provision and protection of their right to consume safe and healthy products.

References

1. Dupouy E. International standards on food safety: their role in stimulating trade and regional contribution into their development / FAO-EUC joint round-table discussion with participation of experts on food safety and trade dedicated to promotion of European-Asian trade integration and aimed at agriculture stability and food safety. Moscow, Russian Federation, September 11, 2013. Websight:http://www.eurasiancommission.org/ru/act/prom_i_agroprom/dep_agroprom/SiteAssets/RU-Dupouy.pdf. [date of visit: September 12, 2014].
2. Zaitseva N.V,, May I.V., Shur P.Z. Kiryanov D.A. Public health risk assessment methodology under the influence of chemical, physical and biological factors for defining products (goods) safety indicators // Health risk analysis. 2014. - No. 3, p. 4-18
3. Guidelines on detection, identification and determination of deoxynivalenol (vomitoxin) and zearalenone contents in grains and grain products: Order of USSR Public Health Ministry dated June 27, 1990 N 5177-90 // Collection of guidelines necessary to provide observation of RF Federal Law dated June 12, 2008 N 88-ФЗ. Part 14. - M.: Rospotrebnadzor Federal Center for Hygiene and Epidemiology. – 2010 г. – 13 p.
4. Commission regulation (EC) No 2073/2005 of 15 November 2005 on microbiological criteria for foodstuffs // Official Journal of the European Union. – 2005. – December. – P. L338/1 – L338/26.
5. Commission regulation (EC) No 401/2006 of 23 February 2006 laying down the methods of sampling and analysis for the official control of the levels of mycotoxins in foodstuffs // Official Journal of the European Union. – 2006. – March. – P. L70/12 – L70/34.
6. Deoxynivalenol in food and feed: occurrence and exposure. Scientific report of EFSA // EFSA Journal. – 2013. – № 11(10):3379. – 56 p.
7. Directive 2001/95/EC of 3 December 2001 on general product safety // Official Journal of the European Co. – 2002. – P. L11/4. – L11/17.
8. Kabak B. The fate of mycotoxins during thermal food processing / B. Kabak // J Sci Food Agric. – 2009. – Vol. 89: 549 –554.
9. Mohamed E. Zain. Impact of mycotoxins on humans and animals / E. Zain Mohamed // Journal of Saudi Chemical Society. – 2011. – Volume 15. – Issue 2. – P. 129–144
10. Regulation (EC) No 178/2002 of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety // Official Journal of the European Communities. – 2002. – P. L31/1 – L. 31/24.
11. Regulation (EC) No 882/2004 of 29 April 2004 on official controls performed to ensure the verification of compliance with feed and food law, animal health and animal welfare rules // Official Journal of the European Union. – 2004. – P. L165/1– L165/141.
12. Schothorst RC. Report from SCOOP task 3.2.10 "Collection of occurrence data of Fusarium toxins in food and assessment of dietary intake by the population of EU memberstates Subtask: trichothecenes / Schothorst RC and van Egmond HP // Toxicology Letters. – 2004. – Vol. 153. – P. 133-143.
13. Scientific Opinion on risks for animal and public health related to the presence of nivalenol in food and feed / EFSA CONTAM Panel (EFSA Panel on Contaminants in the Food Chain) // EFSA Journal. – 2013. – № 11(6):3262. – 119 p.
14. Shephard GS. Fusarium mycotoxins and human health / GS Shephard // Plant Breeding and Seed Science. –2011. –Vol. 64. – P. 113–121.