Scientific Papers. Series D. Animal Science. Vol. LXIII, No. 1, 2020
ISSN 2285-5750; ISSN CD-ROM 2285-5769; ISSN Online 2393-2260; ISSN-L 2285-5750

STUDY ON THE EFFECTIVENESS OF SELF-CONTROL PROGRAMS FOR MYCOTOXINS IN COMPOUND FEED MANUFACTURING

Dragoş Mihai LĂPUŞNEANU[1], Cecilia POP[1], Andreea MUSCĂ[2], Narcisa POSTOLACHE[3], Gabriela FRUNZĂ[1], Cristina RADU–RUSU[1], Ioan Mircea POP[1]

[1]"Ion Ionescu de la Brad" University of Agricultural Sciences and Veterinary Medicine of Iasi, 3 Mihail Sadoveanu Alley, Iasi, Romania
[2]"Vasile Alecsandri" University of Bacau, Calea Marasesti 157, Bacau, Romania
[3]Research and Development Station Bovine Dancu, 9 Iasi-Ungheni Street, Iasi, Romania

Corresponding author email: popmirceais@yahoo.com

Abstract

The self-control program is evidence of one's own supervision in the factory, and may include a variety of analyzes (mycological, mycotoxicological, chemical, spectrophotometric). The aim of the paper is to carry out an analysis of the effectiveness of self-control programs for mycotoxins, between January and June 2019, for a factory laboratory in a feed mill from Romania. Methodologically, the data were processed, analyzed and synthesized in the form of graphs and tables. The results show that during the analyzed period, the self-control program for mycotoxins in the factory laboratory provided a total number of 1080 analyzes to be performed, of which 720 for raw materials, and 360 for compound feed; in fact, 455 analyzes were performed (42.1% of the total), of which 255 for raw materials (35.4%) and 200 for compound feed (55.5%). As a result of the study carried out in the feed mill, it is found that the monitoring of the level of mycotoxin contamination should be increased by increasing the degree of accomplishment of the analyzes proposed in the self-control program.

Key words: *compound feed, mycotoxins, raw materials, self-control program.*

INTRODUCTION

Compound feed production in the European Union - 28 increased by 1.8% in 2018, to 163.3 million tons; the compound feed for poultry has increased production by 1.7% (FEFAC, 2019). The efficient and intensive production of meat, milk, eggs and other foods requires mixed and balanced compound feed. Safe feed allows farmers to ensure food safety, reduce production costs, maintain or increase food quality and consistency, and increase animal health and welfare; they can also reduce the potential for pollution caused by animal waste by providing a certain amount of bioavailable nutrients (FAO and IFIF, 2010).

The compound feed and raw materials can be contaminated with unwanted substances, which can come from the environment and/or from the production process. When animals consume such contaminated feed, contaminants can be transferred to food of animal origin, such as milk, meat and eggs (EFISC, 2014).

Mycotoxins are chemical compounds produced by molds. There are literally hundreds of mycotoxins, some of which are used as antibiotics and are known to us, such as penicillin, others are very dangerous, such as aflatoxins, one of the most powerful carcinogens known (Richard, 2015). FAO (Food and Agriculture Organization) estimated that up to 25% of food in the world is significantly contaminated with mycotoxins (Smith et al., 1994). The emergence of the current mycotoxicology began with the discovery of aflatoxins in peanut flour incorporated in the feed of several animal species, including turkeys and poultry, in England in 1961 (Richard, 2007). More than 350 types of mycotoxins have been identified in nature. They differ in terms of their chemical structure and their biological activity; their action may be: carcinogenic (aflatoxin B_1, ochratoxin A, fumonisin B_1), estrogenic (zearalenone), neurotoxic (fumonisin B_1), nephrotoxic (ochratoxin), dermatotoxic (trichothecenes), immunosuppressive (aflatoxin B_1, ochratoxin A, T-2 toxin) (Pop, 2006).

Given the unavoidable presence of mycotoxins, systematic monitoring of raw materials and finished products intended for human and animal nutrition should be carried out systematically (Psomas and Kafetzopoulos, 2015). Food processing and production include several key points capable of affecting mycotoxin synthesis. Therefore, each technological process for food production and storage should be guided in accordance with the principles of Good Agricultural Practice (GAP), Good Manufacturing Practice (GMP) and systems analysis risks and critical control points (HACCP - Hazard Analysis and Critical Control Points) (Pleadin et al., 2019).

In accordance with Regulation (EC) 183 of 2005 of the European Parliament and of the Council of 12 January 2005 laying down the requirements for feed hygiene, feed companies must establish a self-control procedure and implement self-control programs for their productive activity. The self-control program is the evidence of one's own supervision in factory and may include a variety of analyzes (mycological, mycotoxicological, chemical, spectrophotometric etc.). The self-control program involves the collection of samples by specialized personnel, from the raw materials, from the manufacturing batches, the collection of sanitation tests for the control of the hygiene status of the factory, samples from the water used in the technological process, and their analysis.

The effects of an inappropriate product whose non-conformities have not been identified can be disastrous if they enter the technological process, both for the budget of the organization and for the safety of animals and consumers, which can lead to legal incidents (Pop, 2007).

The aim of the paper is to carry out an analysis of the effectiveness of self-control programs for mycotoxins, between January and June 2019, for a factory laboratory in a feed mill from Romania.

MATERIALS AND METHODS

Methodologically, the self-control programs for mycotoxins from the factory laboratory of a feed mill from Romania were processed, analyzed and synthesized. The self–control programs analyzed corresponded to the period January-June 2019, and the following elements were: mycotoxins to be analyzed, the total number of analyzes proposed to be performed, the number of analyzes to be performed for all raw materials, the number of analyzes to be performed for all types of compound feed; the degree of accomplishment of the analyzes proposed within the mycotoxicological self-control program was monitored for each month from January to June 2019.

To assess the effectiveness of self-control programs for mycotoxins, we followed the results of the analyzes for some raw materials (corn, wheat, soybean meal, sunflower meal) and for the compound feed for broiler in different breeding stages (starter, grower, finisher). The number of analyzes performed and their results were identified, for each month in the set time frame, for each raw material and type of finished product taken into the study.

Quantitative determinations of contamination with: aflatoxin B_1, deoxynivalenol, fumonisin B_1+B_2, toxin T-2, zearalenone, were analyzed, processed, synthesized and interpreted; the quantitative determination of mycotoxins was performed using the ELISA (Enzyme-Linked Immunosorbent Assay) technique.

The results obtained were compared with the maximum level allowed by the European Union legislation.

The interpretation of the data has led to the formulation of conclusions aimed at the elaboration and observance of self–control programs for mycotoxins in compound feed manufacturing.

RESULTS AND DISCUSSIONS

In the production of compound feed, self–control represents the activity carried out by the quality manager, together with all other responsible factors, in order to prevent the introduction of inappropriate raw materials or auxiliaries into the technological process. Within the mycotoxicological self-control program (Table 1), from January to June 2019, for the raw materials and for the compound feed, were determined quantitatively contaminations with aflatoxin B_1, deoxynivalenol (DON), fumonisin B_1+B_2, ochratoxin A (OTA), T-2 toxin (T2), zearalenone (ZEN). For each mycotoxin, a total of 30 analyzes were proposed for each month, of which 20 for raw materials, and 10 for compound feed. Cumulatively, for each month, a number of 180 mycotoxicological analyzes were proposed, of which 120 for raw materials and 60 for compound feed. In January, 58.3% of the 180 proposed analyzes were performed; out of 120 analyzes for raw materials, 54 were performed, and out of 60 analyzes for finished products, 51. In February, 87.2% of the planned analyzes were performed; 71 analyzes were performed for the raw materials, and 86 for compound feed.

Table 1. Mycotoxicological self-control program (factory laboratory)

Month	Mycotoxins analyzed	Proposed analyzes	Analyzes performed %	Analyzes by product category			
				Raw material	Analyzes performed	Compound feed	Analyzes performed
January 2019	Aflatoxin B_1	30	**58.3**	20	14	10	6
	Deoxynivalenol	30		20	9	10	11
	Fumonisin B_1+B_2	30		20	10	10	9
	Ochratoxin A	30		20	0	10	0
	T-2 toxin	30		20	16	10	19
	Zearalenone	30		20	5	10	6
Total		**180**		**120**	**54**	**60**	**51**
February 2019	Aflatoxin B_1	30	**87.2**	20	18	10	28
	Deoxynivalenol	30		20	16	10	20
	Fumonisin B_1+B_2	30		20	10	10	9
	Ochratoxin A	30		20	0	10	0
	T-2 toxin	30		20	10	10	9
	Zearalenone	30		20	17	10	20
Total		**180**		**120**	**71**	**60**	**86**
March 2019	Aflatoxin B_1	30	**14.4**	20	12	10	14
	Deoxynivalenol	30		20	0	10	0
	Fumonisin B_1+B_2	30		20	0	10	0
	Ochratoxin A	30		20	0	10	0
	T-2 toxin	30		20	0	10	0
	Zearalenone	30		20	0	10	0
Total		**180**		**120**	**12**	**60**	**14**
April 2019	Aflatoxin B_1	30	**45.5**	20	15	10	7
	Deoxynivalenol	30		20	15	10	7
	Fumonisin B_1+B_2	30		20	13	10	6
	Ochratoxin A	30		20	0	10	0
	T-2 toxin	30		20	0	10	0
	Zearalenone	30		20	13	10	6
Total		**180**		**120**	**56**	**60**	**26**
May 2019	Aflatoxin B_1	30	**35.5**	20	10	10	4
	Deoxynivalenol	30		20	10	10	6
	Fumonisin B_1+B_2	30		20	6	10	0
	Ochratoxin A	30		20	0	10	0
	T-2 toxin	30		20	14	10	0
	Zearalenone	30		20	10	10	4
Total		**180**		**120**	**50**	**60**	**14**
June 2019	Aflatoxin B_1	30	**11.6**	20	12	10	0
	Deoxynivalenol	30		20	0	10	9
	Fumonisin B_1+B_2	30		20	0	10	0
	Ochratoxin A	30		20	0	10	0
	T-2 toxin	30		20	0	10	0
	Zearalenone	30		20	0	10	0
Total		**180**		**120**	**12**	**60**	**9**
Grand total		**1080**	**42.1**	**720**	**255**	**360**	**200**

In March, 14.4% of the total analyzes were performed; analyzes were performed for aflatoxin B_1 only (12 for raw materials and 14 for compound feed). During April 45.5% of the proposed analyzes were performed; 56 analyzes for raw materials, and 26 for compound feed. In May, the degree of analysis was 35.5%; 50 analyzes were performed for raw materials, and 14 for compound feed. In June, a percentage of 11.6% of the total proposed analyzes was achieved; 12 analyzes were performed for the quantitative determination of aflatoxin B_1 contamination of raw materials, and 9 analyzes for the determination of DON contamination of the compound feed. During the studied time period, no analysis was performed to determine the content of ochratoxin A, which led to a decrease in the percentage of planned analyzes. During the six months taken in the study, the degree of analysis (Figure 1) was fluctuating, and only in two months it exceeded the threshold of 50%.

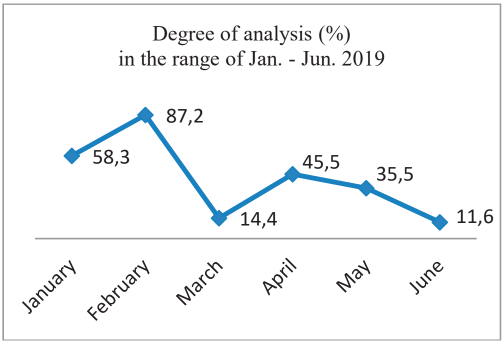

Figure 1. Monthly degree of mycotoxicological analysis from self-control program (%)

In January the level of analysis was 58.3%, followed by an increase in February to 87.2%; in March there was a decrease to 14.4%, followed again by an increase to 45.5% in April; in May and June there were decreases in the number of analyzes, reaching 35.5%, respectively 11.6%.

Between January-June 2019, a total of 455 mycotoxicological analyzes were carried out, of which 255 for raw materials and 200 for compound feed. According to the self-control plan, the total number of analyzes proposed was 1080, of which 720 for raw materials and 360 for compound feed. Considering the data presented above, a general degree of 42.1% of the mycotoxicological analyzes from the self-control program results for the study period.

The results of the analyzes were interpreted and compared with reference to the European Union legislation (Table 2) regarding the maximum permitted limits of mycotoxins in the raw materials and compound feed. The results of the quantitative determinations of mycotoxin contamination (Table 3) for the raw materials (maize, wheat, soybean meal, sunflower meal) and the compound feed for broiler (starter, grower, finisher) indicate that all values are under the limits required by law.

Table 2. Allowed limits for mycotoxins (ppm)

Micotoxyns	Products for animal feed	Maximum permissible limit (ppm)	Normative
Aflatoxin B_1	Feed raw materials	0.02	Reg. EU no. 574/2011
	Compound feed for pigs and poultry, with the exception of young animals	0.02	
DON	Cereals and cereal By-products	8	Rec. EU no. 576/2006
	Maize by–products	12	
	Compound feed for broiler	5	
Fumonisin B_1+B_2	Maize and maize By-products	60	Rec. EU no. 576/2006
	Compound feed for broiler	20	
OTA	Cereals and cereal products	0.25	Rec. EU no. 576/2006
	Compound feed for broiler	0.1	
T-2 Toxin	Cereal based products	0.5	Rec. EU 165/2013
	Compound feed for broiler	0.25	
ZEN	Cereals and cereal products	2	Rec. EU no. 576/2006
	Maize by-products	3	
	Compound feed for pigs	0.25	

For the raw materials studied, 223 mycotoxicological analyzes were performed during the Jan.-June 2019. For the maize 76 analyzes were performed, representing 34% of the total; for 10 analyzes (13.1%) the content of mycotoxins was undetectable. There were 63 analyzes for grain (28.2% of the total); for 7 analyzes (11.1%) the results were non-quantifiable. During the period studied, 53 analyzes (23.1 % of the total) for soybean meal were performed; for 8 analyzes (15%) the content of mycotoxins was undetectable. During the study period, 31 mycotoxicological analyzes were performed for sunflower meal (13.9% of the total); two analyzes (6.4%) had undetectable results.

For compound feed for broiler (starter, grower, finisher) taken in the study, between Jan.-June 2019, 116 mycotoxicological analyzes were performed. During the study period, 33 analyzes (28.4% of the total) were performed for starter compound feed; for 3 analyzes (9%) the content of mycotoxins was undetectable. There were 41 analyzes (35.3% of the total) for grower compound feed; for 5 analyzes (15.1%) the results were non-quantifiable. For the finisher compound feed, 42 mycotoxicological analyzes were performed (36.2% of the total); undetectable results were recorded for 6 analyzes (14.2%).

Table 3. Results of mycotoxicological analyzes (min.-max.)

Product	Month	No. of analyzes	Micotoxyns (ppm)				
			Aflatoxin B_1	DON	Fumonisin B_1+B_2	T-2 Toxin	Zearalenone
Raw materials							
Maize	Jan.	19	0.0010-0.0035	0.035-0.147	0.230-0.310	0.007-0.076	0.015-0.051
	Feb.	12	0.0010-0.0140	0.122	undetectable	undetectable	0.010-0.039
	Mar.	8	0.0007-0.0009	–	–	0.005-0.023	–
	Apr.	18	<0.0006	0.110-0.355	0.053-0.116	–	0.0015-0.0605
	May	15	0.0004-0.0013	0.077	–	0.0076-0.0455	–
	Jun.	4	0.0007-0.0021	–	–	–	–
Wheat	Jan.	10	0.0013-0.0029	0.080-0.095	0.343	0.013-0.410	0.028
	Feb.	8	0.001-0.008	0.072-0.192	0.020	undetectable	0.002-0.660
	Mar.	5	0.0005	–	–	0.007-0.008	–
	Apr.	4	<0.0006	0.144	0.063	–	0.0169
	May	31	0.0005-0.0025	0.002-0.052	undetectable	0.0125-0.0811	0.0021-0.0065
	Jun.	5	0.0002-0.0007	–	–	–	–
Soybean meal	Jan.	7	–	0.064	0.170-0.236	0.014-0.055	–
	Feb.	24	0.0015-0.0089	0.042-0.063	undetectable	0.025-0.048	0.045-0.080
	Mar.	5	0.0008	–	–	0.040-0.043	–
	Apr.	12	<0.0006	0.185-0.262	0.010-0.090	–	0.0031-0.0454
	May	4	0.0014	0.074-0.313	–	–	0.0312
	Jun.	1	0.001	–	–	–	–
Sunflower meal	Jan.	2	–	0.012	–	0.016	–
	Feb.	14	0.0019-0.0060	0.041-0.100	undetectable	0.006-0.010	0.013-0.029
	Mar.	2	0.0019	–	–	0.019	–
	Apr.	12	0.0006-0.0029	0.100	0.001-0.058	–	0.0019-0.0630
	May	0	–	–	–	–	–
	Jun.	1	0.0033	–	–	–	–
Total		**223**					
Compound feed							
Starter	Jan.	11	0.0028-0.0033	0.105-0.111	0.120-0.150	0.009-0.086	0.058-0.061
	Feb.	13	0.0013-0.0080	0.066-0.070	0.020	0.050-0.053	0.021-0.093
	Mar.	2	undetectable	–	–	0.016	–
	Apr.	4	0.0007	0.170	0.008	–	0.0185
	May	3	0.0011	0.070	–	–	0.0122
	Jun.	0	–	–	–	–	–
Grower	Jan.	6	–	0.126-0.154	0.231	0.013-0.051	–
	Feb.	18	0.0007-0.0050	0.057-0.083	undetectable	0.008-0.088	0.023-0.083
	Mar.	7	0.0006	–	–	0.010-0.018	–
	Apr.	6	0.0006-0.0010	0.168-0.224	0.029	–	0.205
	May	4	0.0011	0.090-0.094	–	–	0.0065
	Jun.	0	–	–	–	–	–
Finisher	Jan.	10	0.0031	0.134-0.156	0.244-0.665	0.007-0.051	0.057
	Feb.	24	0.0006-0.0040	0.008-0.080	0.012	undetectable	0.017-0.076
	Mar.	3	0.0012	–	–	0.020	–
	Apr.	4	<0.0006	0.152	0.096	–	0.0297
	May	1	–	0.072	–	–	–
	Jun.	0	–	–	–	–	–
Total		**116**					

CONCLUSIONS

Effectiveness represents the degree of accomplishment of the planned activities. In this study, effectiveness refers to the degree of accomplishment of the activities planned in the self-control program for mycotoxins in the factory laboratory from a feed mill.

In terms of contamination with aflatoxin B_1, deoxynivalenol, fumonisin B_1+B_2, T-2 toxin, and zearalenone, all quantitative determinations of raw materials and compound feed, had results that met the parameters specified in Rec. 576/2006, Reg. 574/2011, and Rec. 165/2013.

The self-control program for mycotoxins from the factory laboratory provided for the period January-June 2019 a total of 1080 analyzes, of which 720 for raw materials, and 360 for compound feed. Out of the total analysis proposed, 455 were carried out, of which 255 for raw materials and 200 for compound feed. As a percentage, 42.1% of the total proposed analyzes were performed, 35.4% of the proposed analyzes for the raw materials, and 55.5% of the proposed analyzes for the compound feed.

During the period January-June 2019, for the quantitative determination of contamination with the five types of mycotoxins, for the four raw materials studied, 223 analyzes were performed (87.4% of the total raw materials analyzed). For the three types of compound feed for broiler, 116 analyzes were performed to determine the five types of mycotoxins (58% of the total compound feed analyzed).

In the present study, at the reception of the four raw materials analyzed, for mycotoxins were identified values that fall under the limits allowed by the legislation; taking into consideration the homogenization of the raw materials for obtaining the compound feed, the mycotoxins can accumulate and can reach or exceed the maximum values established in the regulations.

As a result of the study carried out in the feed mill, it is found that the monitoring of the level of mycotoxin contamination should be increased by increasing the degree of accomplishment of the analyzes proposed in the self-control programs. The degree to which self-control programs for mycotoxins are fulfillment is of major importance, as an improperly identified unidentified product can have adverse effects on the health of animals and consumers.

REFERENCES

EFISC (2014). *European Guide to good practice for the industrial manufacture of safe feed materials 3.1*. Brussels.

FAO and IFIF (2010). *Good practices for the feed industry - Implementing the Codex Alimentarius Code of Practice on Good Animal Feeding*. FAO Animal Production and Health Manual Rome, 9, 8.

Fédération Européenne des Fabricants d'Aliments Composés (FEFAC), (2019). *Annual Report 2018-2019*. Bruxelles.

Pleadin, J., Frece, J., Markov, K. (2019). Advances in Food and Nutrition Research, Vol 89. Academic Press (Ed.), *Mycotoxins in food and feed* (pp. 297–345). London, UK: Elsevier Publishing House.

Pop, C. (2007). *Quality management/Managementul calității*. Iasi, RO: Alfa Publishing House.

Pop, I. M. (2006). *Feed additives/Aditivi furajeri*. Iasi, RO: TipoMoldova Publishing House.

Psomas, E.L., Kafetzopoulos, D.P. (2015). HACCP Effectiveness Between ISO 22000 Certified and non-Certified Dairy Companies. *Food Control*, 53. 134–139.

Recommendation of 17 August 2006 on the presence of deoxynivalenol, zearalenone, ochratoxin A, T-2 and HT-2 and fumonisins in products intended for animal feeding (576/2006).

Recommendation of 27 March 2013 on the presence of T-2 and HT-2 toxin in cereals and cereal products (165/2013).

Regulation (EC) No 183/2005 of the European Parliament and of the Council of 12 January 2005 laying down requirements for feed hygiene.

Regulation (EU) No 574/2011 of 16 June 2011 amending Annex I to Directive 2002/32/EC of the European Parliament and of the Council as regards maximum levels for nitrite, melamine, Ambrosia spp. and carry-over of certain coccidiostats and histomonostats and consolidating Annexes I and II thereto.

Richard, J.L. (2007). Some major mycotoxins and their mycotoxicoses - An overview. *International Journal of Food Microbiology*, 119, 3–10.

Richard, J.L. (2015). Romer Labs' Guide to Mycotoxins. Richard, J.L. (Ed.), *Mycotoxins - an overview* (pp. 1–48). Leicestershire, England.

Smit, J.E., Lewis, C.W., Anderson, J.G., Solomons, G.L. (1994). *Mycotoxins in human nutrition and health*. Directorate General XII, Science, Research and Development. European Commission.