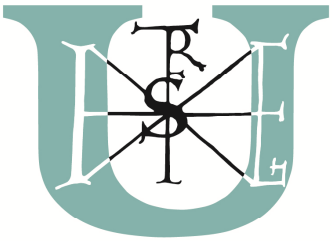

SZENT ISTVÁN UNIVERSITY

FACULTY OF FOOD SCIENCE

Fusarium mycotoxin contamination in Hungary with particular attention to climate change

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Budapest

2018

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The applicant met the requirement of the PhD regulations of the Szent István University and the thesis is accepted for the defence process.

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1. BACKGROUND INFORMATION ON THE RESEARCH AND THE OBJECTIVE

The climate change affects our daily lives, our direct environment - animals, plants alike - and consequently, it indirectly impacts the agriculture and the food industry. Based on our scientific knowledge, the climate change is a constant phenomenon in world history, but the rate of acceleration of these changes significantly increased in the last 40-50 years. Its primary cause is due to elevated appearance of anthropogenic effects on our planet. The average temperature showed an increase of +0.74°C between 1905 and 2005.

Based on meteorological data the temperature rose faster inside the continent than above the ocean; however, these differences have appeared most remarkably in recent decades. Scientists can only estimate the expected increase in the average temperature of our planet by using climate models, of which the most uncertain part is to know the degree of anthropogenic activity in the future. As a result, numerous screenplays have surfaced, among which there are ordinary, optimistic and pessimistic ones also. The pessimistic can be backed up by the fact that the world's population has been increasing to an explosive extent. Today roughly ~7.5 billion people live on our planet, and the majority inhabits the poorer, economically underdeveloped areas of these countries, the population of Africa is ~1.2 billion, that of Asia is ~4.4 billion and the more developed Europe currently has "only" ~739.000 000. The data seems also frightening, because most of the population lives on continents that will use most likely environment polluting energies - to enhance their economic performance, and because of the enormous number of people - to support and survive.

The significance of climate change is outstanding, that's why it is essential to examine its effects on the areas of food science so that we can try to prepare ourselves for a not-yet-known phenomenon and strive to decrease the damages done against the food industry and food economy. Primarily, not the vulnerability of food industry or the economic loss, but the human life and the protection of human health must prevail. Climate change-related food science research is of strategic importance for many countries. Hungary is also very devoted to reduce the anthropogenic effects contributing to climate change as well as to preserve our freshwater resources.

The starting point for my doctoral dissertation is the climate change, and its impact on the development of *Fusarium* mycotoxin contamination in Hungary.

Among *Fusarium* mycotoxins, my aim was to investigate changes in deoxynivalenol (DON), zearalenone (ZEN), T-2 contaminants that causes serious economic and health issues throughout Europe.

In my paper I examined the degree of contamination of DON, ZEN (F-2), T-2 mycotoxins in ingredients of food and feed industries using competitive ELISA method. During my research I chose ingredients that are important for nutrition, such as wheat, corn, barley, oats; and from animal feed: soy bean, alfalfa pellet, wheat, barley corn, and mixed feed (pig feed) samples. My thesis deals with the temperature changes in the past decades, including detailed climate change of Hungary between the period of 2008 and 2015. I studied the change in DON mycotoxin contamination using mathematical statistics methods in wheat, corn, wheat flour and pasta product between the period of 2008 and 2015. During the examination, it was determined that weather conditions such as temperature and precipitation distribution have an effect on the degree of DON toxin contamination detected in wheat and corn. Analysing wheat samples, I defined a new risk factor, which is extremely dry weather condition, meaning very low annual rainfall.

The purpose of the dissertation is to establish a research area for the Hungarian food science, which is an analysis of mycotoxin contamination results with respect to climate change (2008-2015) and may serve as a basis of similar research carried out later, even after several years or decades.

The results and conclusions presented throughout my research are useful in today's and tomorrow's comparison of climate change and mycotoxin contamination change occurring in Hungary.

I defined the following objectives for my doctoral work:

1. Weather data analysis, mycotoxin contamination assessment

- testing domestic plant materials, mixed feed, foodstuffs (wheat flour, pasta products) for DON, ZEN, T-2 mycotoxin contamination
- assessing the results by comparing the average concentration of these three toxins using statistical analysis, marker mycotoxin research
- defining marker mycotoxin from the assessed results of the three selected toxins by using statistical methods

2. Evaluation of DON mycotoxin contamination in Hungary by the help of data mining

- creating data table from the DON measurement results assessed between 2008 and 2015, which can be compared with Hungarian weather data and later it can be broadened with

new measurement results that allow comparison with later weather data to provide basis for tracking the degree of change.

- analysing detailed domestic weather condition data between 2008 and 2015, in seasonal breakdown
- comparison and analysis of DON toxin results with domestic weather conditions (2008-2015)
- climate change – determining and describing the correlation with DON mycotoxin contamination, and identifying possible weather factors with regard to the increasing degree of contamination.

2. MATERIAL AND METHOD

Sampling, sample preparation

Samples

The number of samples used for my research is Σ n=1019. The samples used in the first part of this experiment (section 3.1) were the following: n=29 wheat; n=29 corn; n=29 oat; n=29 barley, total Σ n=116 samples tested and evaluated.

In the second part (section 3.2) I divided the samples into two study groups. In the first study group n=20: soy bean, alfalfa pellet; in the second study group n=20 wheat, barley and corn samples were used, Σ n=40.

For the third part of my research (section 3.3), I used pig feed samples of three different manufacturers Σ n=45. I chose the feedstuffs based on different gender and age groups, therefore piglet, sow and boar feed were examined. Per manufacturer n=15 samples were submitted for laboratory testing.

In the next evaluation (section 3.4) I assessed the test results of samples taken from n=305 wheat, n=108 corn, n=179 wheat flour, n=226 dry pasta; Σ n = 818.

Sampling

To make objective assessment for mycotoxin contamination of samples to be tested, the proper execution of sampling is fundamental. The sample selection occurred as set by the Hungarian authorities' sampling procedure, in which the amendments concerning cereals and cereal products can be found in EU Regulation 519/2014. The regulation prescribes the official sampling methods and relevant quantities as well as the findings of sampling and analysis methods used by the Commission to control mycotoxin contamination in foodstuffs. The above mentioned regulation is a modification of regulation 401/2006/EK, which divided sampling concerning cereals and cereal products into two groups based on the quantities of samples taken. Two main groups can be determined based on lot weight, sub-sample numbers, and combined sample weight: samples of lots greater than 50 tonnes and with less than 50 tonnes. In my research the number of sub-samples was 3 and the combined sample weight was 1 kg.

Sample preparation

There was no need to dry the samples. I ground the examined samples into fine mill on a grain size of 1.0 mm. (Tecator, Sweden). The sample preparation for DON, ZEN, T-2 mycotoxins happened according to manufacturer instructions (R-Biopharm).

I proportioned 5 grams of DON mycotoxin as sample (ground, blended) into tightly sealed glass container, then with 100 ml of distilled water, I had the solution strongly stirred for 30 minutes on a shaker machine (Tecator). The mixture was filtered through a glass funnel and Whatman 1 filter into a 100 ml Erlenmeyer flask. I used 50 µl of this mixture for testing: RIDASCREEN® FAST DON.

With regard to ZEN and T-2 mycotoxins the sample preparation protocol is identical, so I used the same working solution for the tests. I proportioned 5 grams of sample into 100 ml flask adding 25ml of 70% MeOH, then I had the solution heavily stirred for 30 minutes on a shaker machine. I filtered the mixture through a glass funnel and Whatman 1 filter into a 100 ml Erlenmeyer flask. I took 1 ml of the filtrate to which I poured 1 ml distilled water. I used 50 µl from this diluted water for the tests: RIDASCREEN® FAST Zearalenon, RIDASCREEN® FAST T-2. During my examinations I completed paralel (n=2) sample preparation.

Indirect competitive ELSA kits

DON kit: RIDASCREEN® FAST DON (Art. No.: R5902, 48 wells), standard solutions: 0 - zero standard: blank solution without mycotoxin -mg/kg, 0,222 mg/kg, 0,666 mg/kg, 2 mg/kg, 6 mg/kg.

Zearalenon kit: RIDASCREEN® FAST Zearalenon (Art. No.: R5502, 48 wells) standard solutions: 0 - zero standard: blank solution without mycotoxin - µg/kg , 50 µg/kg, 100 µg/kg , 200 µg/kg, 400 µg/kg.

T-2 kit: RIDASCREEN® FAST T-2 (Art. No.: R5302, 48 wells) standard solutions: 0 - zero standard: blank solution without mycotoxin - µg/kg, 50 µg/kg, 100 µg/kg, 200 µg/kg, 400 µg/kg.

Quality certificate is provided to each kit. Details of manufacturer/dealer R-Biopharm DG, Darmstadt, Germany. For my measurements, I used Metertech - 500 spectrophotometer (ELISA Reader), with measurement absorbance 450 nm. The standard solutions required for the validation of the methods were of Sigma-Aldrich Chemie GmbH quality (Steinheim,

Germany). The evaluation of results were done by using special software: RIDA® SOFT Win (Art. No.: Z9999).

Statistical methods

The statistical methods interpret our acquired knowledge, information, and test results.
The different standard program packages ensure the prompt and multi-faceted examination of our data. In Statistics, the phenomena under examination are called population. The population can be divided into different groups, and the units' characteristics define their nature. When evaluating my results I took into consideration the samples contaminated with <LOQ mycotoxins.
The statistical analysis of my test results were fulfilled by the help of *RStudio* (Version 0.99.447) and *SPSS* (IBM SPSS Statistics V24) program packages.

Categorizing weather data

I categorized Hungarian weather data based on the homepage of OMSZ/National Meteorological Service. With the help of categorization I could characterize the seasons and years of the weather.

3. RESULTS

3.1. Mycotoxin contamination of grains

When assessing the data, I also took into consideration samples containing mycotoxins over the limit of detection (>LOD), I set these results according to the LOQ values of the given toxin, and calculated the average concentration based on that.

The results for DON toxin are one order of magnitude higher than that of ZEN and T-2, except in DON and T-2 values for corn, where the difference is up to two orders of magnitude.

According to the Commission regulations, the limit laid down for corn is 1750 µg/kg in case of DON, 350 µg/kg in case of ZEN, and 100 µg/kg in case of T-2 toxin. My test results showed that n=4 samples were contaminated with DON above the limit. The ZEN toxin contamination for the same n=4 corn sample was also higher, above the limit. (the limit: 350 µg/kg). The T-2 contamination could be detected regarding n=2 sample, which were taken from samples n=4 equally contaminated with DON and ZEN (measured highest concentration value above limit: 146 µg/kg).

In case of wheat samples n=1 sample was contaminated higher than the limits for DON (1250 µg/kg), it was 1880 µg/kg.

For laboratory cost calculations (ELISA), assigning DON mycotoxin as the mycotoxin marker can be of significant importance. Based on my results it can be determined in which cases it is necessary to test further for ZEN or T-2 toxins besides running test for DON. These were samples contaminated with DON to a higher degree or above the limit. Examining samples further for ZEN after being contaminated with DON above the limit, can serve to identify the causes for symptoms, problems of animal and human health, such as feed refusal, in case of animal feed, or gastrointestinal symptoms and problems of reproductive biology.

When DON contamination appears way above the limit it serves as the marker for ZEN toxin, the appearance of ZEN contamination and also the possibility of appearance above limit. The examination of T-2 toxin is necessary when DON and ZEN taken together appear above the threshold.

Assessing the 2013 weather data my own results indicate that hot, wet climate affects the trends of DON, ZEN, T-2 contamination in the developmental stage of certain grains.

3.2. *Fusarium* contamination of plant based raw materials

For my tests, I used n=20: soy and alfalfa pellet in the first test group; n=20: wheat, barley, and corn in second group (Σn=40). I created two groups because toxin contamination to a varied extent is plausible in grains and other vegetable ingredients used for feeding, thus the consolidated evaluations could have distorted my results.

The evaluation clearly demonstrate that the average and median values of deoxynivalenol have a greater presence (an order of magnitude) here as well compared to ZEN and T-2 mycotoxins that strongly supports DON toxin to be used as the marker as opposed to the other two toxins examining the total sample selections. From this data it can be concluded that DON has the greatest contaminating impact on feed materials (the same as on grains), and it is followed by ZEN, then finally T-2 (in this case the maximum values were compared separately as well).

With regard to both examined groups, contracting concentration values as per toxin samples was possible because every single sample produced similar results (in order of magnitude). The aim of my paper was not describing mycotoxin contamination per matrix, but researching the marker toxin.

3.3. DON, ZEN, T-2 contamination of mixed pig feed

My aim was to reveal the interconnections of mycotoxins, their contamination correlations (marker mycotoxin), and their occurrence in pig feed as feed mix. I examined three big Hungarian feed manufacturers' products. The manufacturers were marked with *X, Y, Z*. Feed samples of three swine groups were used, that of sow, boar and piglet. From each manufacturer, n=15-15-15 sample was examined in the laboratory (Σn=45 in total). My investigations showed toxin contaminations over the limit in all of the samples.My investigations showed toxin contaminations over the limit in all of the samples.

As for sow feeds my results indicated that in products by all three manufacturers (*X,Y,Z*) the contamination for DON, ZEN, T-2 were below the threshold, however, it was over the detection limit (>LOD) in each sample.

With regards to boar feed, the concentration of DON mycotoxin was over the depressive value in all samples (depressive value: 400 µg/kg), and as well as that of ZEN mycotoxin (depressive value: 150 µg/kg), but the level of contaminations did not reach toxic values in case of *Y* manufacturer. The depressive values were never exceeded in case of T-2 toxin. The

boar feed sold by the other 2 feed manufacturers (*Y, Z*) showed contamination below the allowed value (depressive). Regarding the piglet feed, the values were always adequate, below the depressive level in the feed stuff produced by each manufacturer.

The DON toxin, in context with mycotoxins being over guideline values (depressive value), can be designated as the marker toxin regarding ZEN toxin, but there was a need for further analytic statistics to prove that.

I pursued additional exploratory statistical analysis to demonstrate the marker nature of DON toxin. The analyses showed that the DON, as toxin marker regarding ZEN toxin not only when the contamination was over the limit of detection, but it also indicated ZEN contamination even in samples contaminated below the level of detection. Consequently, in case of DON mycotoxin contamination, the presence of ZEN toxin is highly probable in the sample matrices

The DON contamination in pig feed is one order of magnitude higher than those of the other two mycotoxins. The contamination degree of Zearalenone and T-2 toxins were similar, at magnitude ten (10-100 µg/kg). The Deoxynivalenol toxin was proven to be marker in boar feed contaminated to a higher value than $n=5$ depressive value regarding Zearalenone toxin, but not an indicative value regarding T-2. In terms of food safety, it is an awareness raising fact that all three mycotoxins were present in all samples in detectable level (>LOD).

3.4. DON contamination occurrence

During my research, I examined the contamination of DON mycotoxin in grains – wheat, corn – and food products – flour, dry pasta - in a longer period between 2008-2015 in Hungary.

I compared the results (obtained from data mining – authority database) with Hungarian climatic data (official publications supplied by the Hungarian Meteorological Service: Atmosphere, scientific journal, (y/2008-2015, i:53-61) and assessed them (categorized).

As I sorted the information obtained from official database, I found that in the publications of results done with different measuring methods, it was nowhere mentioned whether the values were detectable or not. Reporting the results, even if there was no detectable contamination, always indicated as being <LOQ. Accordingly, the results could be assessed, however it is also likely that contamination would be estimated to a higher extent because the non-detectable samples could not be set for LOD value. In the Authority's database the measurement standards could be traced regarding the samples (their results), thus reaching LOD values could be highly possible.

All in all, it can be stated that I was able to consider and calculate with each sample throughout my evaluation with using the above mentioned method.

Through my research it was found that the meteorological conditions such as temperature, rainfall and precipitation patterns were all factors of DON toxin contamination in wheat and corn. Analyzing wheat samples, I was able to determine another risk factor, which in my opinion was the extremely dry weather (very low average rainfall). Examining the DON toxin contamination in corn samples, besides annual rainfall and precipitation quantity, I found a further factor, namely, the very warm temperature experienced throughout the year. It can be concluded that besides the weather conditions matrix defined so far (previous research done on wheat and corn) for determining DON toxin contamination, there is a need to consider "other extreme weather conditions" when it comes to plan the monitoring inspections. This is particularly important in the future, when weather forecasts (coming from WMO, OMSZ) warn us about the frequent occurrence of extreme weather conditions, and also the rise in the Earth's average temperature.

3.5. New scientific results/thesis

1. With my measurements and the Hungarian weather data I was able to prove higher level of toxin contamination in grains in context with the warm climate.

2. My examinations defined DON toxin as marker toxin in case of ZEN toxin when samples were contaminated above the limit. The DON contamination could be of indicative value for the presence of T-2.

> *(**H. Tima**, A. Taczmann-Brückner, Cs. Mohácsi-Farkas, G. Kiskó: Fusarium mycotoxins in cereals harvested from Hungarian fields. **FOOD ADDITIVES AND CONTAMINANTS PART B - SURVEILLANCE** 9:(2) pp. 127-131. (2016), **IF:1,723**)*

3. When examining *Fusarium* mycotoxin contamination in plant-based raw materials for animal feed, I was able to define DON toxin as the marker toxin and prove its marker characteristic in different sample matrix where samples are contaminated below guideline values. The DON, used as marker toxin can help measurements done with ELISA method in cost planning and efficiency.

> *(**H. Tima**, E. Kecskésné Nagy, A. Rácz, G. Kiskó, Cs. Mohácsi-Farkas: Takarmányozásra használt növényi alapanyagok DON, F-2, T-2 mikotoxin vizsgálata ELISA-módszerrel/ DON, F-2 and T-2 mycotoxin assay of plant-based feedstock raw materials using the ELISA method. **ÉLELMISZERVIZSGÁLATI KÖZLEMÉNYEK** 63:(2) pp. 1548-1563. (2017).)*

4. When examining DON, ZEN, T-2 contamination in pig feed, DON was proven to be the marker toxin for ZEN in samples contaminated under and above depressive value. Generally analyzing the marker toxin nature of DON in various sample matrices (in grains, in different raw materials for animal feed, grain based pig feed), it was proven that the matrix effect/matrix composition can be eliminated by defining the marker toxin.

> *(**H. Tima**, A. Rácz, Zs. Guld, Cs. Mohácsi-Farkas, G. Kiskó: Deoxynivalenol, zearalenone and T-2 in grain based swine feed in Hungary. **FOOD ADDITIVES AND CONTAMINANTS PART B - SURVEILLANCE** 9:(4) pp. 275-280. (2016), **IF= 1,723**)*

5. I identified the extreme weather conditions as new risk factor with regard to DON contamination. I established data tables that could be of further use, and the results compared with recent times are accessible to help forecasting risk of DON contamination in connection with climate change.

(***H. Tima***, *A. Berkics, Z. Hannig, A. Ittzés, E. Kecskésné Nagy, Cs. Mohácsi-Farkas, G. Kiskó: Deoxynivalenol in wheat, maize, wheat flour and pasta: surveys in Hungary in 2008-2015.* ***FOOD ADDITIVES AND CONTAMINANTS PART B - SURVEILLANCE*** *11(1): pp. 37-42. (2018), 2017:* ***IF=2,407***)

4. CONCLUSTIONS AND SUGGESTIONS

Among the *Fusarium* mycotoxins, the multi toxic emergence of DON, ZEN and T-2 toxins has an outstanding importance also, and the actual occurrence of these, the contamination degree of these in certain sample matrices give such a new, wide picture about the Fusarium mycotoxins that have been examined less thoroughly before. At the same time. I used samples originating from Hungary and processed in Hungary that gives a comprehensive view of the presence of Fusarium mycotoxins in Hungary (2008-2015).

My research gave evidence that DON toxin is the marker toxin among DON, ZEN, T-2 mycotoxins which was supported not only by its chemical stability shown in previous research, but also my research in which it was used with high frequency as sample. During the measurements it was proven that DON toxin can be designated as the marker toxin among the three mycotoxins: DON, ZEN, T-2. Further analyses are required in the future with other analytic methods. My research gave way for the examination of this area in a deeper way and also the necessity of similar research.

Defining marker toxins in practical use serve to enhance cost efficiency, quicker analyses and faster results. In the future there is a need to use various mathematical statistics method to analyze the interconnections of DON, ZEN, T-2 contaminations and to compare these.

The main direction of my research paper to provide a situational picture of *Fusarium* mycotoxins in Hungary, in particular to give a presentation about DON, ZEN, T-2 toxins, furthermore to analyze the domestic climatic factors in connection with mycotoxin contamination. My large scale research with many samples gave a representative picture of domestic mycotoxin contamination. This analysis can prove the connections between mycotoxin contamination and climate change I consider important to pursue further similar research in the future. My work could serve as basis of researching the effect of DON contamination in Hungary between 2008-2015 in the context of climatic change, thus its usefulness will repay for the future. The information outlined here could give the explanation for the rate of acceleration of domestic climate change and its effect on the development of mycotoxin contamination in Hungary, therefore provides the opportunity to prepare for and defend against elevated mycotoxin contamination.

Based on my analyses it can be stated that the great deal of results set found in the Autorities' database could be used for research purposes. It is not only that we can access data going back years, but that these measurements are certified and also taken from reliable sources. However, in order to make targeted use of the results, along with publicizing the

measurements' results it would be also necessary to indicate whether the given mycotoxin was detectable or not in the sample (and not only to provide <LOQ value per the given measurement method).

5. LIST OF PUBLICATIONS REGARDING THE THESIS

In journals with impact factor

Helga Tima, Adrienn Berkics, Zoltán Hannig, András Ittzés, Eleonóra Kecskésné Nagy, Csilla Mohácsi-Farkas, Gabriella Kiskó
Deoxynivalenol in wheat, maize, wheat flour and pasta: surveys in Hungary in 2008-2015
FOOD ADDITIVES AND CONTAMINANTS PART B - SURVEILLANCE 11:**(1)** pp. 37-42. (2018) (2017: **IF=2,402**)

Helga Tima, Andrea Brückner, Csilla Mohácsi-Farkas, Gabriella Kiskó
Fusarium mycotoxins in cereals harvested from Hungarian fields
FOOD ADDITIVES AND CONTAMINANTS PART B - SURVEILLANCE 9:(2) pp. 127-131. (2016) (**IF=1,723**)

Helga Tima, Anita Rácz, Zsuzsanna Guld, Csilla Mohácsi-Farkas, Gabriella Kiskó,
Deoxynivalenol, zearalenone and T-2 in grain based swine feed in Hungary
FOOD ADDITIVES AND CONTAMINANTS PART B - SURVEILLANCE 9:(4) pp. 275-280. (2016) (**IF=1,723)**

E Kecskésné Nagy, Helga Tima, P Korzenszky, P Sembery
Színválogatás után keletkezett malmi melléktermék DON-toxin-tartalmának vizsgálata takarmányként való felhasználás szempontjából
MAGYAR ÁLLATORVOSOK LAPJA **138:**(7) pp. 421-430. (2016) (**IF=0,212**)

Hungarian journals without impact factor

Tima Helga, Kecskésné Nagy Eleonóra, Rácz Anita, Kiskó Gabriella, Mohácsiné Farkas Csilla
Takarmányozásra használt növényi alapanyagok DON, F-2, T-2 mikotoxin vizsgálata ELISA-módszerrel/DON, F-2 and T-2 mycotoxin assay of plant-based feedstock raw materials using the ELISA method
ÉLELMISZERVIZSGÁLATI KÖZLEMÉNYEK **63:**(2) pp. 1548-1563. (2017)

Tima Helga, Radványi Dalma
Penészes romlások kimutatásának lehetőségei
ŐSTERMELŐ: GAZDÁLKODÓK LAPJA **2015:**(4) pp. 39-41. (2015)

Szabóné Tima Helga
Penészesedés és mikotoxin termelés hatása a gabonafélékre
ŐSTERMELŐ: GAZDÁLKODÓK LAPJA **1:** pp. 52-53. (2014)

Szabóné Tima Helga
Klímaváltozás hatása a penészgombákra és a mikotoxin termelésre
ŐSTERMELŐ: GAZDÁLKODÓK LAPJA **3:** pp. 32-33. (2014)

Szabóné Tima Helga
DON, F-2, T-2 mikotoxinok megjelenésének kockázata az élelmiszerláncban
***ŐSTERMELŐ: GAZDÁLKODÓK LAPJA* 6:** pp. 119-120. (2014)

Szabóné Tima Helga
Sertések mikotoxin érzékenysége
***ŐSTERMELŐ: GAZDÁLKODÓK LAPJA* 5:** pp. 110-111. (2013)

Szabóné Tima Helga
Mikotoxinok élelmiszerbiztonsági kockázata
***ŐSTERMELŐ: GAZDÁLKODÓK LAPJA* 6:** pp. 134-135. (2013)

Szabóné Tima Helga
Baromfiak mikotoxin érzékenysége
***GALAMB ÉS KISÁLLAT MAGAZIN* 27:**(11) pp. 10-11. (2013)

English conference paper

Tima Helga, Rácz Anita, Mohácsi-Farkas Csilla, Kiskó Gabriella
Exploration of DON, F-2, T-2 contamination of vegetal raw materials used for feeding, analysis of their food safety risks
In: Ács Kamilla, Bencze Noémi, Bódog Ferenc, Haffner Tamás, Hegyi Dávid, Horváth Orsolya Melinda, Hüber Gabriella Margit, Kis Kelemen Bence, Lajkó Adrienn, Mátyás Mónika, Szendi Anna, Szilágyi Tamás Gábor (szerk.)
V. Interdiszciplináris Doktorandusz Konferencia Konferenciakötet: **5th Interdisciplinary Doctoral Conference Book** 514 p.

Konferencia helye, ideje: Pécs, Magyarország, 2016.05.27-2016.05.29.

(ISBN:978-963-429-039-1)

Tima Helga, Taczmanné Brückner Andrea, Mohácsi-Farkas Csilla, Kiskó Gabriella
The occurance of Fusarium mycotoxins in case of cereals harvested from two regions of Hungary
In: Engelhardt Tekla, Dalmadi István, Baranyai László, Mohácsi-Farkas Csilla (szerk.)
Food Science Conference 2015 - Integration of science in food chain: **Book of proceedings**.

Konferencia helye, ideje: Budapest, Magyarország, 2015.11.18-2015.11.19.

Budapest: Corvinus University of Budapest, 2015. pp. 253-255.

(ISBN:978-963-503-603-5)

English conference abstract

Tima Helga, Rácz Anita, Guld Zsuzsanna, Mohácsiné Farkas Csilla, Kiskó Gabriella
Food safety risk of Deoxynivalenol, Zearalenone, T-2 Mycotoxins in swine feed from three manufacturers in Hungary
In: K. Márialigeti, O. Dobay (szerk.)
17 th International Congress of the Hungarian Society for Microbiology. 241 p.
Konferencia helye, ideje: Budapest, Magyarország, 2015.07.08-2015.07.10.
Budapest: Akadémiai Kiadó, pp. 228-229.

Hungarian conference abstract

Szabóné Tima Helga
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In: Szabó István, Bohonyi Noémi, Haffner Tamás, Horváth Orsolya, Márhoffer Nikolett, Molnár Emese, Pál Eszter, Schaub Anita, Varga Zoltán (szerk.)
IV. Interdiszciplináris Doktorandusz Konferencia 2015: **4th Interdisciplinary Doctoral Conference** 2015. 570 p.
Konferencia helye, ideje: Pécs, Magyarország, 2015.05.14-2015.05.15. (Pécsi Tudományegyetem Doktorandusz Önkormányzat)
Pécs: Pécsi Tudományegyetem Doktorandusz Önkormányzat, 2015. p. 25.
(ISBN:978-963-642-830-3)

Tima Helga, Berkics Adrienn, Hannig Zoltán, Ittzés András, Kecskésné Nagy Eleonóra, Mohácsi-Farkas Csilla, Kiskó Gabriella
Deoxinivalenol mikotoxin szennyezettség elemzése búzában, kukoricában, búzalisztben és száraztésztában: felmérés Magyarországon, 2008-2015 között.
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