The effect of processing temperature and time on zearalenone concentration from maize products

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VALERIA GAGIU[1], MIHAELA AVRAM[1], NASTASIA BELC[1],ENUTA IORGA[1], MARIANA DIACONU[2], ALECU DIACONU[2], MIHAI PRICOP[3]

1. Institute of Food Bioresources, 6 Dinu Vintilă Street, 2nd district, Bucharest, Romania, Phone: 040212109128, Fax: 040212113639, E-mail: bioresurse@adslexpress.ro
2. Technical University „Gh. Asachi" – Iaşi, Polytech - Research and Technological Transfer Centre, 59 Mangeron Street, Iaşi
3. SCDA Podul Iloaiei, 87 Naţională Street, Iaşi

Abstract

Mycotoxin contaminated food represent a risk for human and animal health. The best way to protect consumers against toxic effects of fungi and mycotoxins from cereals is to apply HACCP system during production and storage.

As processing is one of the methods for food decontamination, we tested the effect of processing temperature and time on zearalenone mycotoxin from contaminated maize. For this aim, 3 maize samples (naturally contaminated with ZON) were tested at 175^{0}C, 200^{0}C and 225^{0}C and 15, 20, 25 and 30 min, respectively; there were obtained 36 samples that were tested for ZON concentration, using Ridascreen®Zearalenon test kit. Results showed that ZON was stable at 175^{0}C, for 15 – 25 min, but concentration decreased at 200^{0}C, after 20 min. It was thought that this situation is due to the fact ZON is a compound very stable at high temperature, as it is mentioned in literature.

Keywords: zearalenone, contamination, maize, temperature, time, processing

Introduction

Zearalenone [ZON, 6 (10-hydroxy-6-oxo-trans-1-decenyl)-β-resorcyclic acid lactone] is a fungal metabolite produced especially by *Fusarium graminearum* Schwabe and *F. culmorum, F. cerealis, F. equiseti* and *F. semitectum* (4; 8). ZON is an white cristaline substance, with a moleculare weight of 318,4 Dalton, very stable to high temperature (164^{0}C) (9).

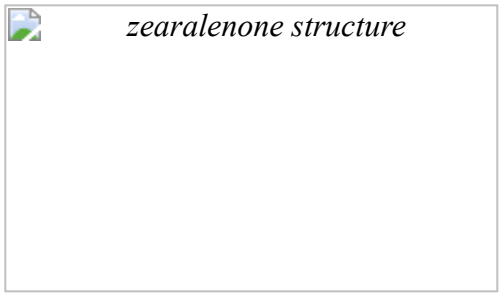

Figure 1. Structural formula of ZON

ZON production occurs as a result of *Fusarium* contamination of cereals in field or during cereal, food and feed storage. Increasing humidity during cereal storage may lead to high levels of ZON, which seems to be an indicator of the presence of other *Fusarium* mycotoxins (e.g. deoxynivalenol) (3; 2). Among cereals, the high frequency of ZON contamination is in maize (3; 5), but in the most situations ZON concentration were lower (2).

ZON has carcinogenic, estrogenic and anabolic properties, and can produce fertility and reproduction problems, especially in pigs (4). This mycotoxin is not classified as carcinogenic to humans [it is included in group 3 by IARC (International Agency for Research on Cancer)], but it was implied in precocious sexual development in children (2). Because of biological effects, ZON needs to be closely monitored in food and feed (6).

Theoretically, there are three possibilities to avoid the effects of food and feed contamination with mycotoxins: cereal breeding, food and feed decontamination (by chemical preservatives, microorganisms,

processing and essential oils); inhibition of food mycotoxins absorption in intestinal tract (1).

Processing can decrease but not eliminate mycotoxins from cereal food and the risk associated to them (7; 13). *Fusarium* contaminated cereals and their mycotoxins represent a risk for human health but decrease technological properties of cereals (10). During physical processing, mycotoxin decontamination rate depends on their distribution in food, chemical properties, as well as on their solubility and thermal stability (11). Ryu & al [12] studied thermal stability of ZON in buffered aqueous solution; ZON decreasing was determined during thermal processing (100^0C, 125^0C, 150^0C, 170^0C, 200^0C and 225^0C), in buffered aqueous solution which had different pH values. ZON decreasing rate was increased with processing temperature being complete in less then 30 min, at 225^0C, not taking into account pH value. Generally, ZON presented the highest stability at pH 7, followed by pH 4 and 10; the most evident decrease of ZON was registered at temperatures over 175^0C.

The aim of these experiments was to determine the effect of temperature and time processing on zearalenone mycotoxin concentration from maize processed for human food.

Materials and Methods

The efect of processing temperature and time on ZON mycotoxin concentration was determined on 3 maize samples which were selected from 11 experimental samples (after a 7 month storage period), because they presented the highest contamination with zearalenone. These 3 experimental samples were represented by corn cob mixtures V6 (50 % healthy corn cobs + 50 % damaged corn cobs), V10 (10 % healthy corn cobs + 90 % damaged corn cobs) and V11 (100 % damaged corncobs).

Corncob mixtures were ground using a Retsch ZM 200 ultracentrifugal mill (18000 rpm, fitted with a conidur sieve of 2 mm) and obtaining full fat maize flour as processed products.

ZON concentrations from maize flour were analised by immunoenzimatic Ridascreen®Zearalenon test kit (ppt = ng kg^{-1}), according to the R – Biopharm protocol (14). Absorbance was measured at 450 nm by microplate reader Sunrise (Tecan, Austria), fitted with RIDAWIN software (R - Biopharm).

Results and Discussions

To establish the time and temperature parameters for processing, we performed preliminary experiments using different full fat maize flour, temperatures of 175^0C, 200^0C or 225^0C and times of 20, 30, 40 or 50 min. These temperature values were selected because ZON is a very stable compound at high temperature (164^0C) and literature is mentioning a decrease of ZON contamination during thermal treatment, decreasing rate being complete in less then 30 min, at 225^0C. Visual examination of obtained samples led to conclusion that 40, 50 min respectively are not suitable because the sample is burned, color compounds affecting in a negative way the ELISA method for ZON detection.

As a result of these observations, futures experiments were performed for corn cob mixtures V6, V10 and V11, thermally treated at 175^0C, 200^0C, or 225^0C, for 15, 20, 25, or 30 min; 36 experimental samples were obtained. Also, to have a control sample, from each corncob mixture (V6, V10, V11) 2 subsamples were extracted; finally, 42 samples were analyzed for ZON concentration.

Preparation procedure for experimental samples was the following: 400 g full fat maize flour from each sample were mixed with 600 mL distilled water; mixture was homogenized and heated for 5 min to obtain a pasty firmness. From the 3 mixtures, 12 subsamples were weighed (75 g/subsample) and thermally processed at 175^0C, 200^0C, or 225^0C, for 15, 20, 25, or 30 min. Thermal treatment of samples was performed simultaneously in 3 laboratory ovens with forced aeration. After thermal treatment, samples were cooled down in 3 desiccators, ground by a laboratory coffee mill and weighed.

ZON concentration from the 42 samples was determined using a Ridascreen®Zearalenon test kit (ng kg^{-1}) and optical density was measured at 450 nm. ZON concentrations (ng kg^{-1}) were calculated based on a "cubic spline" calibration curve and transformed in μg kg^{-1}.

As seen in figure 2, ZON concentration was still high after 30 min, regardless of processing temperature (175^0C, 200^0C or 225^0C). Nevertheless, it was thought that results are not relevant because the samples were burnt and color compounds affected immunoenzimatic reaction leading to a low optical density (for ELISA method, low value for optical density correspond to a high concentration of analyt).

For all experimental samples, ZON concentration not decreased at 175^0C, for 15 – 25 min (figures 2, 3), but it decreased after 20 min, at 200^0C and 225^0C (figure 4); related to the control samples, ZON decreasing rate was of 35 % for V6 corn cobs mixture, 28 % for V10 corn cobs mixture and 49 % for V11 corn cobs mixture (average values). Results are according to scientific literature which is mentioning ZON decreasing during thermal treatment.

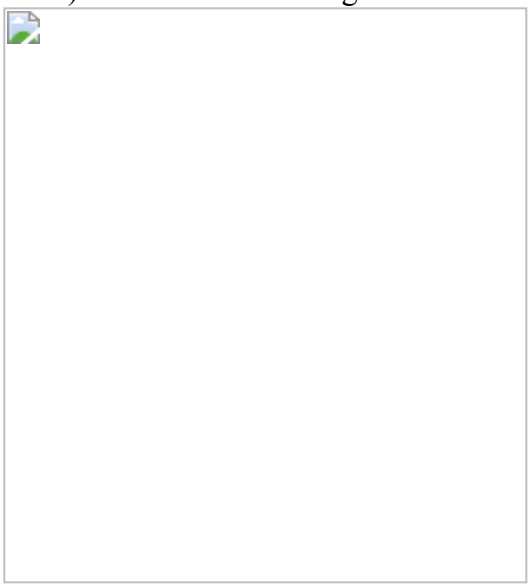

Figure 3. ZON concentration depending on processing temperature

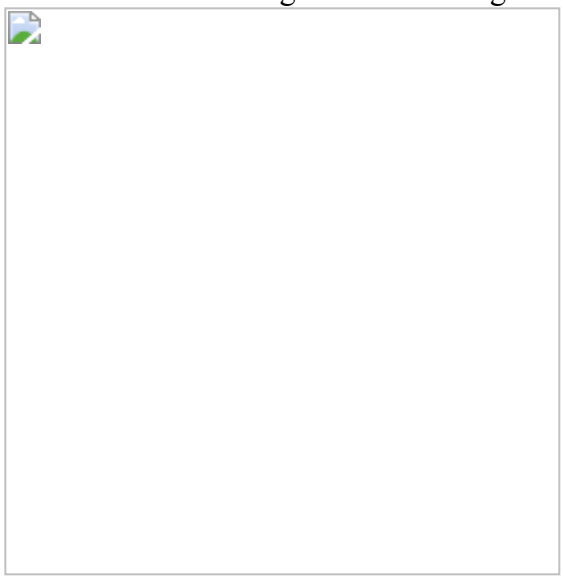

Figure 4. ZON concentration depending on processing time

Conclusions

Experiments were performed to determine the effect of temperature and time processing on ZON mycotoxin from maize samples and showed a decrease in ZON concentration at 200^0C. In all experimental samples, ZON concentration did not decrease at 175^0C, for 15 – 25 min; it was thought that this situation is due to the fact ZON is a compound very stable at high temperature, as it is mentioned in literature.

Acknowledgments

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References

1. A. BATA, R. LÁSZTITY, *Trends in Food Science &Technology* **10**, 223 – 228 (1999).
2. D.J. BUENO, G. OLIVER, *Methods Mol. Biol.* **268**, 133 – 137 (2004).
3. L. DE SAEGER, L. SIBANDA, C. VAN PETEGEM, *Analytica Chemica Acta* **487**, 137 – 143 (2003).
4. FAO/WHO. Position paper on zearalenone. Joint FAO/WHO Food Standard Programme. Codex Committee on Food Additives and Contaminants. Thirty – second Session, Beijing, People's Republic of China, 20 – 24 March 2000.
5. J.M. GAREIS, J. BAUER, C. ENDERS, B. GEDEK, Taxonomy, Pathogenicity 441 – 472 (1989).
6. M.T. LIU, B.P. RAM, J.J. PESTKA, *Appl. Environm. Microbiol.* **50** (2), 332 – 336 (1985).
7. G.A. LOMBAERT, *Adv. Exp. Med. Biol*. **504**, 141 – 153 (2002).
8. M.L. MARTINS**,** *Food Chemistry* **79**, 315 – 318 (2002).

9. H. PICHLER, *PhD thesis*, Viena, Austria (**1999**).
10. A. PRANGE, B. BIRZELE, J. KRÄMER, A. MEIER, H. MODROW, P. KOEHLER, *Food Control* **16**:739-745 (2005).
11. D. RYU, L.S. JACKSON, L.B. BULLERMAN, *Adv. Exp. Med. Biol.* **504**, 205 – 206 (2002).
12. D. RYU, M.A. HANNA, K.M. ESKRIDGE, L.B. BULLERMAN, *J. Agric. Food Chem*. **51** (6), 1746 – 1748 (2003).
13. D.M. TRIGO – STOCKLI, *Adv. Exp. Med. Biol*. **504**, 181 – 188 (**2002**).
14. R - Biopharm. Ridascreen®Zearalenon test kit, User guide