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Research Article

Contamination of Corn (Zea mays) and Millet (Pennicetum Glaucum) Porridge Sold on the Streets of Abidjan by Zearalenone

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Abstract

Zearalenone is a carcinogenic contaminant frequently found in cereal-based foods. This study aimed to determine the level of zearalenone contamination in maize and millet porridges sold in the municipality of Yopougon, Abidjan. It was a cross-sectional study. Five grams of ground material from each of the ten samples were extracted with 50 ml of ultrapure water and 50 ml of dichloromethane. After filtration and decantation, zearalenone was detected and quantified by HPLC-FLD. It was detected in four (4) of the five (5) millet porridge samples, with a minimum concentration of 1.65 µg/kg, a maximum concentration of 61.38 µg/kg, and a mean concentration of 18.24 µg/kg. Regarding maize porridge, zearalenone was detected in all five (5) samples, with a minimum concentration of 1.87 µg/kg, a maximum concentration of 7.30 µg/kg, and an average concentration of 4.86 µg/kg. According to reference values, the zearalenone content of the maize porridge is acceptable. However, for millet porridge, three (3) samples met the standards for infants and four (4) samples met the standards for adults. This study highlights the presence of zearalenone in porridge sold in the Yopougon district. Since porridge is a food widely consumed by children and adults, the risk associated with zearalenone is almost constant for the Ivorian population. It is therefore important to reduce the risk of contamination of maize and millet slurries by zearalenone through good production, storage and processing practices, involving actors in the millet and maize value chain.

Keywords

Corn, Contamination, Millet, Porridge, Zearalenone

1. Introduction

Cereals are the most important food source for humans [1] due to their high sugar, protein, vitamin, and mineral content [2, 3]. Among cereals, millet and corn processed into flour are used to make porridge.

The consumption of porridge based to corn and millet flour is widespread in Africa, constituting a staple food for many

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populations, particularly in semi-arid regions.

Corn and millet are staple grains for human consumption in Africa, particularly in areas where climate change is making it more difficult to grow other grains. These grains are crucial to ensuring food and nutritional security for millions of people, especially poor populations [4].

In Côte d'Ivoire, millet and corn porridges commonly known as “baca or coco baca” are primarily intended for adult consumption and are part of the dietary habits of the peoples of northern Côte d'Ivoire. They are also used as complementary foods for children [5].

The consumption of corn and millet porridge in Africa poses health risks. Indeed, improperly stored grains are often contaminated with mycotoxins, including carcinogenic aflatoxins, which are produced by molds. These mycotoxins can persist in the porridge and become potentially hazardous to consumers’ health. During production, storage, and processing, these grains are susceptible to be contaminated by filamentous fungi [6].

Filamentous fungi have remarkable potential for producing secondary metabolites [6]. These compounds are frequently used in the pharmaceutical industry (penicillin, statins, etc.). Some of these metabolites, known as mycotoxins, are toxic to humans. Produced mainly by molds of the genera *Aspergillus*, *Fusarium*, and *Penicillium*, which contaminate many raw materials, mycotoxins are the most common natural contaminants found in food [7]. These toxins are highly resistant to various food manufacturing and processing methods, including cooking. For example, deoxynivalenol is still stable at 120 ℃ and is only destroyed after heat treatment at 210 ℃ for 30 minutes. As a result, mycotoxins end up on our plates. The strategy for combating mycotoxins must therefore be based on preventing fungal contamination and applied at all stages of food production (pre-harvest, raw materials, processed foods, etc.) [8].

Among these mycotoxins, zearalenone has a prominent place due to its frequency of detection in cereals, particularly corn [9, 10].

Zearalenone is synthesized by certain fungi of the genus Fusarium, which frequently contaminate crops such as corn, barley, wheat, oats, millet, and rye, in temperate and warmer climates [11, 12]. Furthermore, it has been shown that, under conditions of very high humidity (74%), *Aspergillus oryzae*, *A. parasiticus*, and *A. versicolor* could also produce the toxin in wheat grains [13]. It can be biotransformed into numerous modified forms with varying degrees of toxicity. Zearalenone therefore has pleiotropic toxicity that depends on the target organ (whether or not it responds to estrogen) and the conditions of exposure (low or high dose) [14, 15]. In animals, the toxic effects of zearalenone on the reproductive system are well known and include infertility, hormonal dysfunction, and hyperplasia of the reproductive tract in farm and laboratory animals [16]. In humans, exposure to zearalenone has been associated with endometrial hyperplasia, while the metabolite α-zearalenol may be capable of promoting the development of breast cancer. Zearalenone is also toxic to other organs, such as the liver, immune cells, and intestines [17].

Data exists from industrialized countries such as France. In West Africa, studies have been conducted on mycotoxins, sometimes including zearalenone [18, 19]. However, none have systematically assessed zearalenone levels in street-sold porridges in Côte d'Ivoire, yet evaluating exposure to this mycotoxin is crucial for consumer protection. In this context, knowledge of the zearalenone content of foodstuffs in general, and porridges in particular, is essential. The objective of this study was therefore to assess the level of zearalenone contamination in millet and maize-based porridges. The research hypothesis was that millet and maize-based porridges contain zearalenone at high concentrations.

2. Material et Methods

2.1. Biological material

The biological material used in this study consisted of ready-to-eat corn and millet flour porridges (Figure 1).

Figure 1. *Woman selling porridge (millet and corn) on a sidewalk.*

2.2. Methods

2.2.1. Sampling

Samples of millet and corn porridge, weighing approximately 200 g each, were collected in the municipality of Yopougon (Abidjan) more specifically in the Lokoua and Terminus 27 districts. In this municipality, the porridge samples were collected from vendors (two vendors, five samples per vendor, and 10 samples in total) chosen at random in markets and on sidewalks. To avoid contamination, the samples were carefully placed in stomacher bags, then transferred to the laboratory and stored in a freezer at -4 ℃ until analysis.

This is a pilot study with the objectives of testing the sampling methodology, getting an idea of the contamination of street food by zearalenone and validating the feasibility of a larger study.

2.2.2. Extraction of Zearalenone

A quantity of 5 g of the ground material was taken from a

200 ml flask, then 50 ml of ultrapure water and 50 ml of dichloromethane were added. The mixture obtained was homogenized using an Ultra Turax mixer and stirred. After 30 minutes of stirring, the extract was filtered through filter paper (WHATMAN). The solution obtained was transferred to a 500 ml separating funnel and shaken vigorously. The organic phase (dichloromethane) was collected in a round-bottom flask in order to evaporate this solvent using a rotary evaporator. Once the extraction solvent had evaporated, the residues contained in the flask were dissolved in acetonitrile and then transferred to a vial for detection and quantification by HPLC-FLD. All solutions used during this study were acquired from Carbo Erba (France) and had a purity of 99%.

2.2.3. Detection of Zearalenone by HPLC

The chromatographic conditions for detecting zearalenone by HPLC-FLD were as follows:

1) Flow rate: 1 ml/min;
2) Mobile phase A: acetonitrile (80%);
3) Mobile phase B: ultrapure water (20%);
4) Injection volume: 10 µL;
5) Wavelength: 274 nm;
6) Analysis time: 10 min;
7) Oven temperature: 40 ℃;
8) Elution mode: isocratic;
9) Column type: Kromasil, 5 µm, C18, 100 Å, 250x4.6 mm ID.

In order to construct the calibration curve for zearalenone, a stock solution of zearalenone (500 µg/L in acetonitrile) was prepared by dissolving the zearalenone standard (100 µg/mL in acetonitrile). This stock solution was used to prepare six daughter solutions with zearalenone concentrations of 0 µg/L, 0.25 µg/L, 2.5 µg/L, 25 µg/L, 50 µg/L, 125 µg/L, and 250 µg/L. The peak areas of these different concentrations were obtained using HPLC-FLD. These concentrations were recorded and a simple linear regression between the concentrations of the standard solutions and their peak areas (*peak area (Y) = f (concentration)*) was performed. The coefficient of determination (R^2) and the probability associated with Fisher's test were determined in order to assess the quality of the linear regression model.

2.2.4. Quantification

Using the model, the equation of the linear regression line (Y = a X + b), where Y is peak area and X is zearalenone concentration; a: slope coefficient and b: y-intercept), the zearalenone (Co) content of the extracts was determined, and then the zearalenone content of the samples was obtained using the following expression:

$$C_{zen} = \frac{(C_0 \ x \ V_f \ x \ F)}{(T_r \ x \ M)}$$

Where: C_{Zen}: zearalenone content (µg/kg); C_0: zearalenone content (µg/L); V_f: final volume of the extract (L); F: dilution factor; M: mass of the test sample (kg); Tr: recovery rate.

The average recovery rate was determined using the formula below. It varied between 85% and 98%.

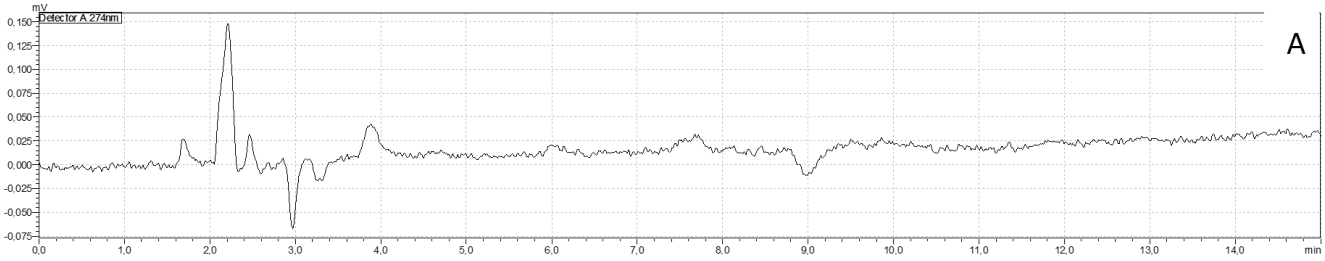
$$Tr \ (\%) = \left(\frac{Concentration \ measured \ after \ extraction}{Theoretical \ concentration \ added}\right) x100$$

The limit of detection (LOD) is 0.083 µg/kg and the limit of quantification (LOQ) is 0.25 µg/kg

3. Results

3.1. Chromatograms of Zearalenone at Different Concentrations

Comparison of the chromatograms of the zearalenone standards with that of the blank (acetonitrile) allowed the peak of this molecule to be identified at 3.96 ±0.20 min (Figure 2).



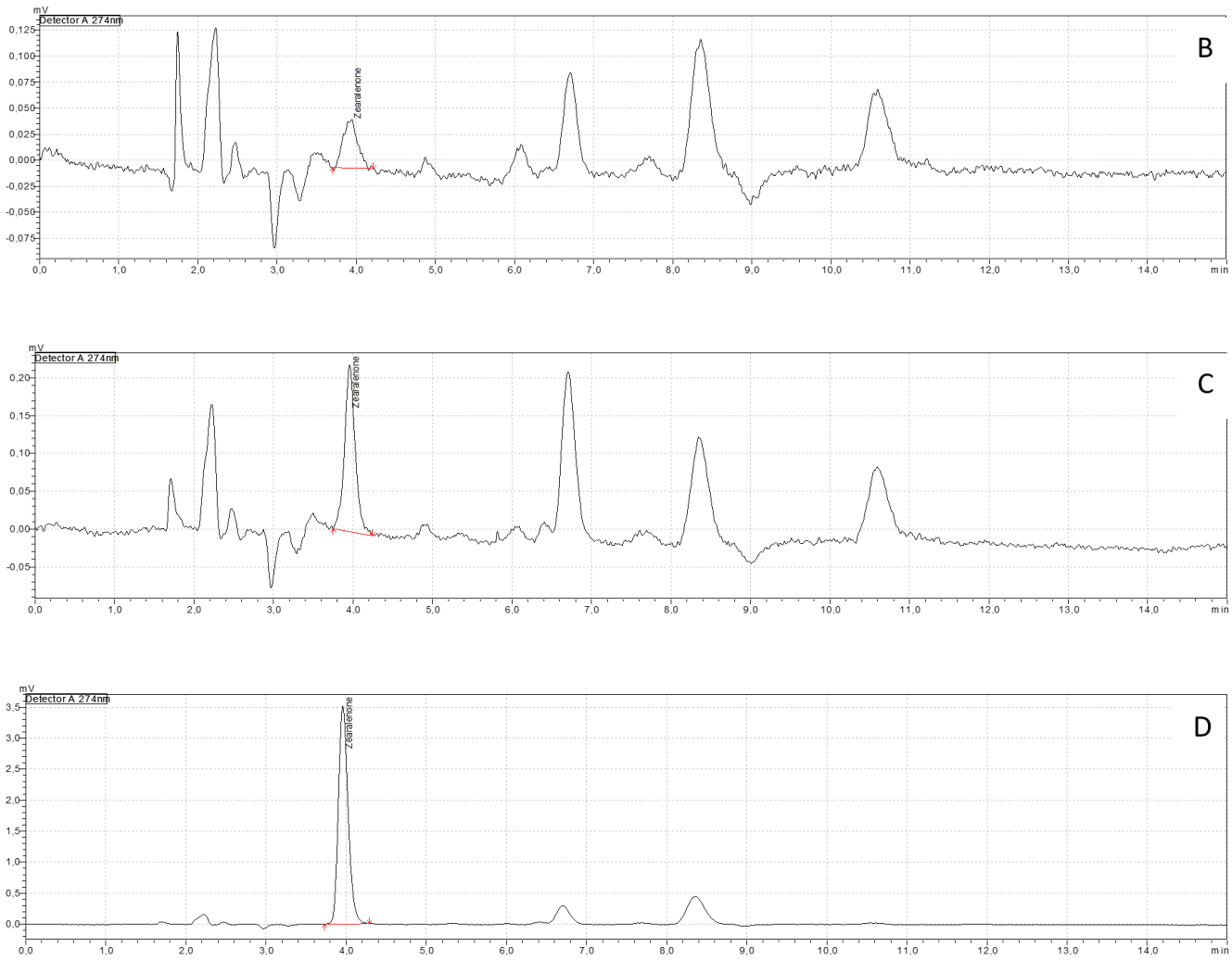


Figure 2. *Chromatograms of zearalenone at different concentrations.*

Chromatogram of acetonitrile (A), Chromatogram of the zearalenone standard (C = 0.25 µg/L) (B), Chromatogram of the zearalenone standard (C = 2.5 µg/L) (C), Chromatogram of the zearalenone standard (C = 50 µg/L) (D)

3.2. Calibration of Zearalenone

The coefficient of determination (R^2) of the calibration curve was 0.9999. In addition, the equation of the linear regression line between concentrations and peak areas was y = 608.44x-172.62, and the probability associated with the Fisher test was less than 5% (p<0.0001). The method for detecting zearalenone is therefore linear in the range 0-250 µg/L (Figure 3).

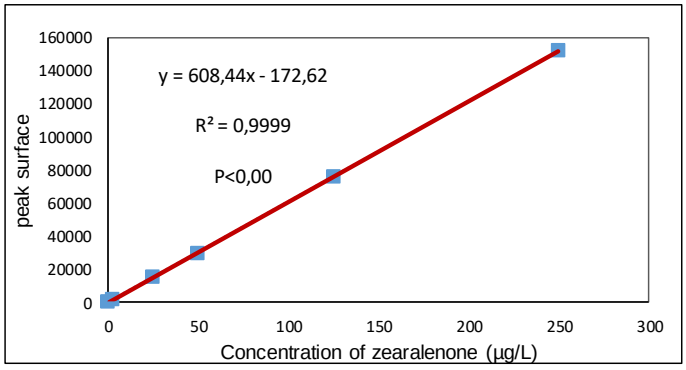


Figure 3. *Zearalenone calibration curve.*

3.3. Zearalenone Levels

The results of the analyses of the samples are shown in Table 1. According to this table, zearalenone was detected in four (4) sample of the millet porridge samples, with a minimum content of 1.65 µg/kg (MIL 4) and a maximum content of 61.38 µg/kg (MIL 2), and the average content was 18.24 µg/kg.

In corn porridge, zearalenone was detected in all samples (100%). The minimum zearalenone content in this porridge was 1.87 µg/kg (Corn 4) and the maximum content was 7.30 µg/kg (Corn 2), with an average content of 4.86 µg/kg.

Table 1. *Zearalenone levels in the samples.*

Corn			Millet		
Code	**Locality**	**zearalenone (µg/kg)**	**Code**	**Locality**	**zearalenone (µg/kg)**
Corn 1	Yopougon Lokoua	4,31 ±0,01[d]	Millet 1	Yopougon TNS 27	5,74 ±0,02[c]
Corn 2		7,30 ±0,01[a]	Millet 2		61,38 ±0,01[a]
Corn 3		6,33 ±0,05[b]	Millet 3		22,43 ±0,01[b]
Corn 4		1,87 ±0,01[e]	Millet 4		1,65 ±0,01[d]
Corn 5		4,51 ±0,01[c]	Millet 5		ND

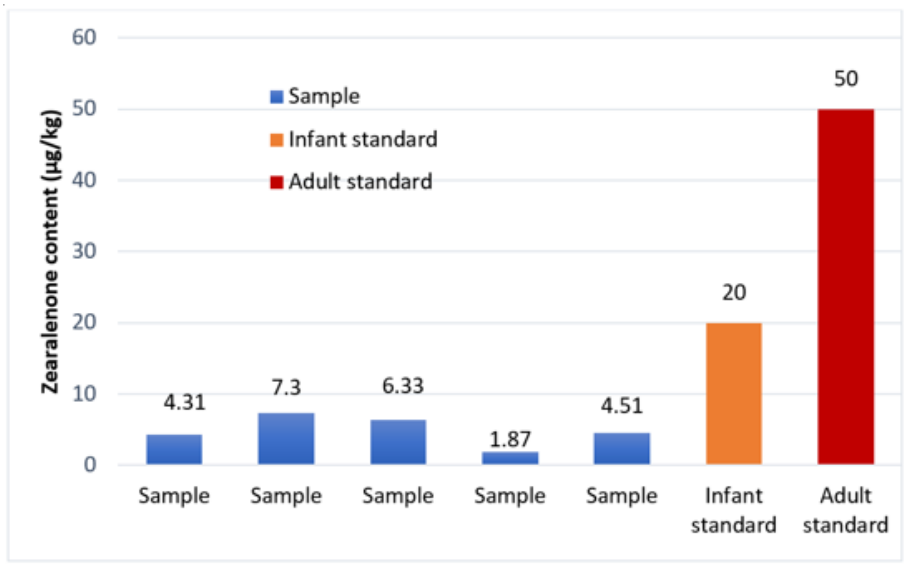
ND: Not Detected; Lokoua and TNS 27 are localities of Yoougon municipality

The values are means ± standard deviations of three measurements (n = 3). On the same line, numbers followed by the same letter are not significantly different at the 5% level according to Tukey's test

3.4. Assessment of the Level of Contamination in Millet and Corn Porridge According to Standard Values

A comparison of the different zearalenone levels against the adult standard (50 µg/kg) and the infant standard (20 µg/kg) showed that all corn porridge samples were acceptable (Figure 4A).

According to the infant standard for zearalenone (20 µg/kg), three (3) samples of millet porridge met the standard. Regarding the adult standard for zearalenone (50 µg/kg), 4 out of 5 samples met the standard (Figure 4B).



Corn (A)

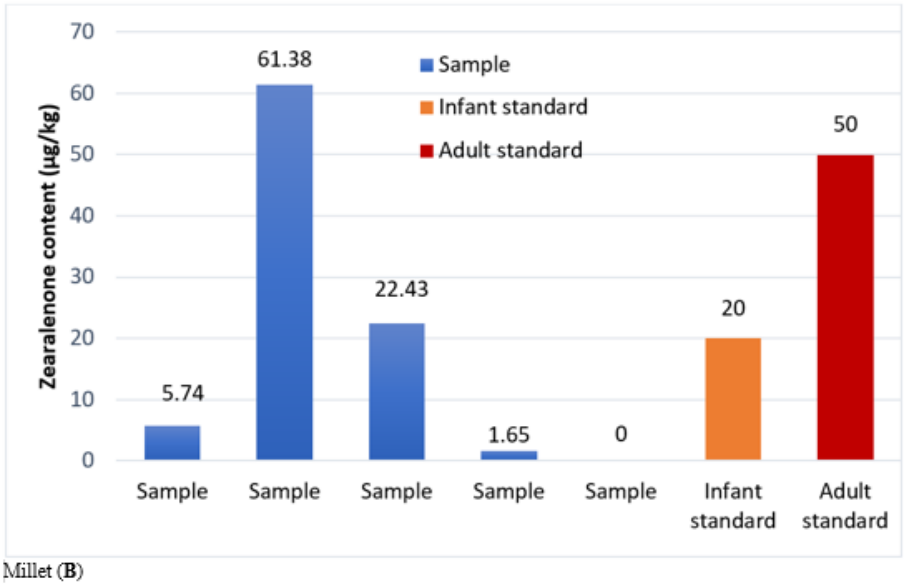


Figure 4. *Comparison of zearalenone levels in corn and millet with standards.*

4. Discussion

The presence of zearalenone in food is a problem in various cereals such as corn, wheat, and barley, as well as in processed products, often due to inadequate storage and drying conditions. Testing for zearalenone content in our samples of millet and corn porridge revealed the presence of this toxin in the porridge. Zearalenone was found to be present in addition to other mycotoxins in samples of rice, maize, and peanuts obtained from Ivory Coast, Africa [18].

In this study, consumer exposure to corn porridge ranges from 1.87 to 7.3 µg/kg and porridge exposure ranges from 0 to 61.38 µg/kg. In Europe, for the most exposed populations (infants and young children), exposure ranges from 0.0115 to 0.0462 µg/kg body weight/day and the tolerable daily intake established by EFSA for zearalenone and its modified forms is 0.25 µg/kg body weight/day. In view of these values, consumers in Ivory Coast are as exposed as those in Europe. Furthermore, a study conducted in Abidjan by Kpan (2023) [20] on cereals (corn and millet) and their porridges revealed significant dietary exposure to zearalenone, a dangerous toxin, particularly among infants and children, suggesting a high health risk associated with their consumption.

Compared to the standard for children (20 µg/kg) and adults (50 µg/kg), 100% of corn porridge samples do not pose a risk to consumers. However, 50% of millet porridge samples are safe for children and 80% are acceptable for adults. Regular consumption of these porridges would increase the risks associated with zearalenone, based on the principle that everything is poison, nothing is poison, it is the dose that makes the poison. The risk is all the greater as the zearalenone levels in these foods often exceed acceptable standards, and is amplified by the combined consumption of cereals and their porridges.

The contamination of these porridges could have several causes. The presence of zearalenone in corn and millet porridges could originate, on the one hand, from the stages of corn and millet production and, on the other hand, from the porridge preparation process. In terms of production, drying and storage are critical points, and failure to control these processes encourages the development of molds that secrete mycotoxins, including zearalenone [21, 22], making the resulting foods undesirable for consumption [23]. Insufficiently dried seeds and drying on the ground promote the proliferation of mold. Storing seeds in damp places at room temperature also promotes the development of mycotoxin-producing molds, including zearalenone [24, 25].

Mycotoxins persist in food even after cooking [26]. Mycotoxin contamination affects both natural and processed products such as cereals, oilseeds, dried fruits, and animal products [27].

Our findings are confirmed by a study conducted in several villages in Tanzania, which showed the presence of several mycotoxins, including zearalenone, in corn-based porridge from certain regions of Tanzania [28].

The contamination of crops with primarily Fusarium species leads to the production of zearalenone that contaminates various food and feed [29]. Exposure to zearalenone can display both acute and chronic effects. The chronic ingestion includes low-dose intake for a long time resulting in decreased productivity and resistance to pathogens and serves as a major concern relating to human and animal health [30]. Zearalenone, a mycotoxin found in food, primarily harms health by causing endocrine disruption due to its estrogenic activity, leading to reproductive issues like infertility, disrupted development of reproductive organs, and problems with sperm in males and ovaries in females. It also causes hepatotoxicity (liver damage), immunotoxicity (harm to the immune system), genotoxicity (DNA damage), and is a potential carcinogen [31,

32]. In addition to zearalenone, the possible presence of other mycotoxins would increase the risks of contamination and constitute a public health risk.

To limit the health impact of zearalenone, consumers should diversify their diet by alternating foods and consuming foods rich in antioxidants. Vendors should improve their preparation practices and receive training on proper porridge-making techniques.

5. Conclusion

This study revealed the presence of zearalenone in maize and millet porridges. Only a few samples showed zearalenone concentrations exceeding tolerance levels. Nevertheless, frequent consumption of contaminated porridges could endanger consumer health. Zearalenone is a potent endocrine disruptor that causes early breast development in young girls, a vulnerability linked to metabolic immaturity, and has carcinogenic effects. It is therefore important to reduce the risk of zearalenone contamination of maize and millet porridges through good production, storage, and processing practices, involving all stakeholders in the maize and millet supply chain.

The limited number of samples and collection sites is the main limitation of this study. We plan to conduct a larger-scale study in terms of the number of samples and municipalities included. We also wish to study the combined effects of other mycotoxins on zearalenone in cereal-based slurries.

Abbreviations

HPLC	High-Performance Liquid Chromatography
EFSA	European Food Safety Authority
DNA	Deoxyribonucleic Acid

Author Contributions

Kouame Nzebo Desire: Conceptualization, Formal Analysis, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing

Traore Moumouny: Conceptualization, Data curation

Benie Comoe Koffi Donatien: Formal Analysis, Investigation

Atobla Koua: Investigation, Visualization

Dadie Adjehi: Formal Analysis, Validation

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Kockova, M., Dilongova, M., Hybenova, E. and Valik, L. Evaluation of Cereals and Pseudocereals Suitability for the Development of New Probiotic Foods. *Journal of Chemistry*. 2013(1). Portico. https://doi.org/10.1155/2013/414303

[2] Fletcher, R. J. Pseudocereals, Overview. *Encyclopedia of Grain Science*. 2004, 488–493. https://doi.org/10.1016/b0-12-765490-9/00133-6

[3] Corsetti, A. and Settanni, L. Lactobacilli in sourdough fermentation. *Food Research International*. 2007, 40(5), 539–558. https://doi.org/10.1016/j.foodres.2006.11.001

[4] Saxena, R., Vanga, S. K., Wang, J., Orsat, V. and Raghavan, V. Millets for Food Security in the Context of Climate Change: A Review. *Sustainability*. 2018, 10(7), 2228. https://doi.org/10.3390/su10072228

[5] Soro-Yao, A. A., Brou, K., Koffi-Nevry, R. and Dje, M. K. Microbiology of Ivorian fermented products: A review. *Asian Journal of Agriculture and Food Sciences*. 2013, 1(2).

[6] Mannaa, M. and Kim, K. D. Influence of Temperature and Water Activity on Deleterious Fungi and Mycotoxin Production during Grain Storage. *Mycobiology*. 2017, 45(4), 240–254. https://doi.org/10.5941/myco.2017.45.4.240

[7] Omotayo, O. P., Omotayo, A. O., Mwanza, M. and Babalola, O. O. Prevalence of Mycotoxins and Their Consequences on Human Health. *Toxicological Research*. 2019, 35(1), 1–7. https://doi.org/10.5487/tr.2019.35.1.001

[8] Eskola, M., Kos, G., Elliott, C. T., Hajslova, J., Mayar, S. and Krska, R. Worldwide contamination of food-crops with mycotoxins: Validity of the widely cited 'FAO estimate' of 25%. *Critical Reviews in Food Science and Nutrition*. 2019, 60(16), 2773–2789. https://doi.org/10.1080/10408398.2019.1658570

[9] Gaumy, J. L., Bailly, J. D., Benard, G. and Guerre, P. Zearalenone: origine et effets chez les animaux elevage. *Revue Med Vét*. 2001, 152(2), 123-136.

[10] Houissa, H. Les Mycotoxines du mil: occurrence et flore fongique (Doctoral dissertation, Universite Montpellier; Universite de Tunis El-Manar. Faculte des Sciences de Tunis (Tunisie), 2020.

[11] Mally, A., Solfrizzo, M. and Degen, G. H. Biomonitoring of the mycotoxin Zearalenone: current state-of-the art and application to human exposure assessment. *Archives of Toxicology*. 2016, 90(6), 1281–1292. https://doi.org/10.1007/s00204-016-1704-0

[12] Caglayan, M. O., Şahin, S. and Üstündağ, Z. Detection Strategies of Zearalenone for Food Safety: A Review. *Critical Reviews in Analytical Chemistry*. 2020, 52(2), 294–313. https://doi.org/10.1080/10408347.2020.1797468

[13] Atalla, M. M., Hassanein, N. M., El-Beih, A. A. and Youssef, Y. A. Mycotoxin production in wheat grains by different Aspergilli in relation to different relative humidities and storage periods. *Food/Nahrung*. 2003, 47(1), 6–10. Portico. https://doi.org/10.1002/food.200390017

[14] Rai, A., Das, M. and Tripathi, A. Occurrence and toxicity of a fusarium mycotoxin, zearalenone. *Critical Reviews in Food Science and Nutrition*. 2019, 60(16), 2710–2729. https://doi.org/10.1080/10408398.2019.1655388

[15] Fruhauf, S., Novak, B., Nagl, V., Hackl, M., Hartinger, D., Rainer, V., Labudova, S., Adam, G., Aleschko, M., Moll, W.-D., Thamhesl, M. and Grenier, B. Biotransformation of the Mycotoxin Zearalenone to its Metabolites Hydrolyzed Zearalenone (HZEN) and Decarboxylated Hydrolyzed Zearalenone (DHZEN) Diminishes its Estrogenicity in Vitro and in Vivo. *Toxins*. 2019, 11(8), 481. https://doi.org/10.3390/toxins11080481

[16] Taranu, I., Braicu, C., Marin, D. E., Pistol, G. C., Motiu, M., Balacescu, L., Beridan Neagoe, I. and Burlacu, R. Exposure to zearalenone mycotoxin alters in vitro porcine intestinal epithelial cells by differential gene expression. *Toxicology Letters*. 2015, 232(1), 310–325. https://doi.org/10.1016/j.toxlet.2014.10.022

[17] Zinedine, A., Soriano, J. M., Moltó, J. C. and Mañes, J. Review on the toxicity, occurrence, metabolism, detoxification, regulations and intake of zearalenone: An oestrogenic mycotoxin. *Food and Chemical Toxicology*. 2007, 45(1), 1–18. https://doi.org/10.1016/j.fct.2006.07.030

[18] Sangare-Tigori, B., Moukha, S., Kouadio, H. J., Betbeder, A.-M., Dano, D. S. and Creppy, E. E. Co-occurrence of aflatoxin B1, fumonisin B1, ochratoxin A and zearalenone in cereals and peanuts from Ivory Coast. *Food Additives and Contaminants*. 2006, 23(10), 1000–1007. https://doi.org/10.1080/02652030500415686

[19] Adejumo, T. O., Hettwer, U.and Karlovsky, P. Survey of maize from south-western Nigeria for zearalenone, α-and β-zearalenols, fumonisin B1 and enniatins produced by Fusarium species. *Food Additives and Contaminants*. 2007. 24(9), 993–1000. https://doi.org/10.1080/02652030701317285

[20] Kpan, K. K. G., Manda, P., Osseke, S. M., Tiho, S. and Ardjouma, D. Dietary exposure to zearalenone in maize and millet grains and their porridges marketed in Abidjan (Ivory Coast). *Food Additives & Contaminants*: Part A. 2023, 40(9), 1264–1274. https://doi.org/10.1080/19440049.2023.2244085

[21] Kappenstein, O., Klaffke, H. St., Mehlitz, I., Tiebach, R., Weber, R., Lepschy, J. and Wittkowski, R. Determination of zearalenone in edible oils with SEC and LC-ESI-MS/MS. *Mycotoxin Research*. 2005, 21(1), 3–6. https://doi.org/10.1007/bf02954804

[22] Wang, Y., Sun, D., Wen, J., Fang, T., Wang, P. and Cheng, F. Influences of corn oil production process on corn gibberellic ketene and vomiting toxins. *Cereal Food Ind*. 2015, 4, 19-22.

[23] Xie, H. Y., Yuan, Y., Yu, H., Zhou, Y., Tan, H. T. and Zhou, H. Simultaneous determination of 15 kinds of mycotoxins and 6 kinds of pesticide residues in cereal-based complementary foods for infants and young children by isotope dilution-ultra performance liquid chromatography-tandem mass spectrometry. 2021, 5306-5313

[24] Chilaka, C., De Boevre, M., Atanda, O. and De Saeger, S. The Status of Fusarium Mycotoxins in Sub-Saharan Africa: A Review of Emerging Trends and Post-Harvest Mitigation Strategies towards Food Control. *Toxins*. 2017, 9(1), 19. https://doi.org/10.3390/toxins9010019

[25] Barbosa-Canovas, G. V., Fontana, A. J., Schmidt, S. J. and Labuza, T. P. Water Activity in Foods. (Eds.). 2020. https://doi.org/10.1002/9781118765982

[26] Bonazzi, C. and Bimbenet, J.-J. Sechage des produits alimentaires - Principes. Agroalimentaire. 2003. https://doi.org/10.51257/a-v1-f3000

[27] Houmairi, H. and Hicham, M. Composition en mycobiota et mycotoxines de type aflatoxines et ochratoxine A de quelques epices dans la region centrale du Maroc. *Journal of Materials and Environmental Science.* 2015, 6(3), 877-884.

[28] Geary, P. A., Chen, G., Kimanya, M. E., Shirima, C. P., Oplatowska-Stachowiak, M., Elliott, C. T., Routledge, M. N. and Gong, Y. Y. Determination of multi-mycotoxin occurrence in maize based porridges from selected regions of Tanzania by liquid chromatography tandem mass spectrometry (LC-MS/MS), a longitudinal study. *Food Control*. 2016, 68, 337–343. https://doi.org/10.1016/j.foodcont.2016.04.018

[29] Poor, M., Kunsagi-Mate, S., Balint, M., Hetenyi, C., Gerner, Z. and Lemli, B. Interaction of mycotoxin zearalenone with human serum albumin. Journal of Photochemistry and Photobiology B: *Biology*. 2017, 170, 16–24. https://doi.org/10.1016/j.jphotobiol.2017.03.016

[30] Cheat, S., Pinton, P., Cossalter, A.-M., Cognie, J., Vilariño, M., Callu, P., Raymond-Letron, I., Oswald, I. P. and Kolf-Clauw, M. The mycotoxins deoxynivalenol and nivalenol show in vivo synergism on jejunum enterocytes apoptosis. *Food and Chemical Toxicology*. 2016, 87, 45–54. https://doi.org/10.1016/j.fct.2015.11.019

[31] Belhassen, H., Jimenez-Diaz, I., Arrebola, J. P., Ghali, R., Ghorbel, H., Olea, N. and Hedili, A. Zearalenone and its metabolites in urine and breast cancer risk: A case-control study in Tunisia. *Chemosphere*. 2015, 128, 1–6. https://doi.org/10.1016/j.chemosphere.2014.12.055

[32] Zhou, J., Zhao, L., Huang, S., Liu, Q., Ao, X., Lei, Y., Ji, C. and Ma, Q. Zearalenone toxicosis on reproduction as estrogen receptor selective modulator and alleviation of zearalenone biodegradative agent in pregnant sows. *Journal of Animal Science and Biotechnology*. 2022, 13(1). https://doi.org/10.1186/s40104-022-00686-3