CODEX ALIMENTARIUS COMMISSION E

Food and Agriculture Organization of the United Nations

World Health Organization

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JOINT FAO/WHO FOOD STANDARDS PROGRAMME

CODEX COMMITTEE ON CONTAMINANTS IN FOODS

9th Session
New Delhi, India, 16 – 20 March 2015

MATTERS OF INTEREST ARISING FROM FAO AND WHO (INCLUDING JECFA)

STATUS REPORT ON THE FAO/WHO PROJECT ON MYCOTOXINS IN SORGHUM SUPPORTED BY THE CODEX TRUST FUND

1. The FAO/WHO project on mycotoxins in sorghum (2012 – 2014), implemented in four participating countries – Burkina Faso, Ethiopia, Mali, and Sudan, is complete. The project resulted from previous discussions in the Codex Committee on Contaminants in Foods (CCCF) on the potential need for a Maximum Level on mycotoxins in sorghum, and was funded by the European Commission through the FAO/WHO Project and Fund for Enhanced Participation in Codex (Codex Trust Fund). Previous status reports on the project have been provided to the 7th and 8th CCCF, and this note provides a brief report on key project results.

2. The project provides i) mycotoxin occurrence data; and ii) information on the sorghum value chain in the four participating countries. The primary objective of the project was to provide mycotoxin occurrence data in sorghum grains, with samples taken at 3 different times along the chain in a one year period – as soon as possible after harvest; immediately prior to wet season; before yearly stocks end. The secondary objective was to collect information on farming practices at the point of sampling through sample data sheets and on sorghum production practices through the value chain study.

3. To ensure consistent data from the four countries, protocols, standardizing the approach on sampling plan, sample collection and preparation, data analysis and value chain methodology were developed. The analysis was done by the Laboratory of Food Analysis at the University of Ghent (ISO 17025 accredited) using a validated multi-analyte LC-MS/MS method (Ediage et al, 2011[1]) allowing simultaneous analysis for 23 mycotoxins[2].

4. The project activities were implemented by four national teams, supported by FAO and WHO staff, and a dedicated project manager. National workshops have been implemented at the end of the project in all countries to discuss the project findings and consider relevant follow up.

MAIN RESULTS FROM SORGHUM SURVEY

5. In total 1 532 sorghum samples were collected across the four countries.

6. The following parameters were analysed for each country:

Percentage **of mycotoxin positive samples** for a country

Percentage **of samples positive for specific compound** for a country

Mean (arithmetic and geometric) & **minimum, maximum for specific compound**

Analysis of **co-occurrence of mycotoxins**

Variability as a function of the **sampling period**

Variability as a function of the **agroecological zone**

[1] E. Njumbe Ediage, J. Diana Di Mavungu, C. Van Peteghem, S. De Saeger. (2011). A validated multi-analyte LC–MS/MS method for the quantification of 25 mycotoxins in cassava flour, peanut cake and maize samples. Journal of Agricultural and Food Chemistry. 59, 5173–5180

[2]: Nivalenol, Deoxynivalenol, Fusarenon X, Neosolaniol, 3-Acetyldeoxynivalenol, 15 Acetyldeoxynivalenol, Aflatoxin G2, Aflatoxin G1, Aflatoxin B2, Aflatoxin B1, Diacetoxyscirpenol, Altenuene, Roquefortin C, HT-2 toxin, Fumonisin B1, Fumonisin B2, Fumonisin B3, Alternariol, T-2 toxin, Ochratoxin A, Zearalenone, Sterigmatocystin and Alternariol-Monomethylether.

Correlations (of contaminant levels) with specific secondary data collected during sampling e.g. variety, colour of grain, storage structure, and others if relevant

7. Detailed project results will be available in the final project report, due for publication in 2015.

8. In total, 16 different mycotoxins were detected, out of the 23 compounds that were tested for with the analytical method. They are Aflatoxin B1 (AFB1), Aflatoxin B2 (AFB2), Aflatoxin G1 (AFG1),Aflatoxin G2 (AFG2), Fumonisin B1 (FB1), Fumonisin B2(FB2), Fumonsin B3 (FB3), Sterigmatocystin (STC), Ochratoxin A (OTA), Diacetoxyscirpenol (DAS), Zealenone (ZEA), HT-2-Toxin (HT2), Alternariol (AOH), AlternariolMonomethylether (AME), Deoxynivalenol (DON) and Altenuene (ALT).

9. Further detail on mycotoxin contamination across the four countries is attached in Table 1., providing the number of positive samples for each mycotoxin, limit of quantification, limit of detection, mean and maximum figures.

10. Summarising the data for all four countries shows the proportion of samples containing at least one of the 16 detected mycotoxins at > LOQ for Round 1 = 31.5%, Round 2 = 32% and Round 3 = 36%.

11. It should be noted that two mycotoxins (i.e. Sterigmatocystin (STC) and Diacetoxyscirpenol (DAS)) that so far have not commonly been detected in Africa were highly prevalent.

12. Information on co-occurrence is provided in Figure 1., showing the number of samples where specific co-occurrences (two) were found for each country. Further available data shows that in approximately half of the positive samples, co-occurrence of more than two mycotoxins is observed.

13. Raw data are accessible in the GEMS food database at: https://extranet.who.int/gemsfood/Search.aspx.

MAIN RESULTS FROM VALUE CHAIN STUDIES

14. The value chain studies showed that sorghum is an essential pillar of livelihoods, allowing farmers to yield on marginal areas where other crops are not productive. In fact areas planted with sorghum have increased over the last years. Overall consumption of sorghum by individuals was found to be relatively high, as sorghum is the basis for a high variety of products (from porridge to beer, with regional preferences for specific products). Sorghum shows medium susceptibility to pest infestation, but grain molds are very common. The causal relationship between mould infestation and mycotoxin contamination is rarely perceived by stakeholders, and contaminated grains can enter the food chain – consumed directly by humans or used as animal feed. However, in areas where previous activities to address mycotoxin contamination of crops (i.e. aflatoxins in groundnuts for example) were implemented, awareness was found to be higher. Production systems are generally low input, using local varieties. A wide variety of storage practices were observed, some being very conducive to fungal infestation. Theft concerns in rural areas may negatively influence drying and storage practices, for instance the use of drying platforms being gradually discontinued, or early threshing of insufficiently dried grains, use of polypropylene bags, use of underground storage systems in order to protect the grains.

15. While each country presents a different set of challenges, the four value chain studies yielded useful information to understand some common trends regarding agricultural practices, at field, harvest and post harvest stages. These were used to prepare a preliminary table (Table 2.), highlighting high and low risk practices that could inform the preparation of a Code of practice.

CONCLUSION AND RECOMMENDATIONS

Considerations for action at national and regional level:

16. This project provides additional data on levels of mycotoxin contamination of sorghum, including some that have so far been little investigated (i.e STC, DAS). It also provides valuable information to support the development of codes of practice with the objective of preventing or reducing the contamination by mycotoxins.

17. However, the following areas of investigation were not addressed in the project:

- samples were gathered for a one year period only. Given the inter-annual variability of mycotoxin contamination, extending the sample collection period to another year would provide additional valuable information.
- the fungal profile was not investigated
- as per project protocol, only grain samples were collected and analysed, and not specific processed sorghum-based products.
- the project did not interpret the results in terms of health risk; further work would be needed on exposure assessment.

18. Table 2. presents a list of practices potentially increasing or reducing contamination. A better assessment of the actual impact of selected recommended practices through controlled trials should be performed.

19. Results from the value chain highlight the need for stakeholders to have clear guidance on good practices, supported by an awareness of the effective health risks of mycotoxins. There is therefore a strong need for a code of practice which would be the basis for training and awareness raising campaigns to support implementation of improved practices throughout the sorghum chain.

Considerations for CCCF action:

20. The Committee is invited to consider the information and data provided, in the context of ongoing or an future work related to: i) determining the suitability and feasibility to establish MLs for selected mycotoxins in sorghum and ii) deciding if the additional information on mitigation measures could be relevant to the ongoing revision of the Code of Practice for the Prevention and Reduction of Mycotoxin Contamination in Cereals.

Table 1: Data on mycotoxins identified in sorghum samples

Mycotoxins	Number of positive samples (% of total samples)	LOD (µg/kg)	LOQ (µg/kg)	Mean (µg/kg)	MAX (µg/kg)	JECFA assessment
Aflatoxins B1	109 (7.11%)	3.75	7.5	41	359	1999
Aflatoxins B2	55 (3.59%)	1.75	2.5	8.5	49	1999
Aflatoxins G1	47 (3.06%)	1.75	2.5	32	714	1999
Aflatoxins G2	6 (0.39%)	3.75	7.5	12	32	1999
Altenuene	1 (0.06%)	12.5	25	44	44	None
Fumonisins B1	182 (11.87%)	12.5	25	272	3419	2011
Fumonisins B2	58 (3.78%)	17.5	35	211	1606	2011
Fumonisins B3	28 (1.82%)	20	40	173	589	2011
HT-2 toxin	1 (0.06%)	5	10	12	11.9	2001
Ochratoxin A	33 (2.15%)	1.5	3	27	163	2007
Deoxynivalenol	7 (0.45%)	20	40	74	112	2011
Zearalenone	42 (2.74%)	3.25	6.5	91	382	2000
Alternariol	47 (3.06%)	40	80	212	1090	None
AlternariolMonomethylether	36 (2.34%)	5	10	63	257	None
Diacetoxyscirpenol	173 (11.29%)	1.25	2.5	6.9	109	None
Sterigmatocystin	246 (16.05%)	1.25	2.5	56	1189	None

Figure 1. Co-occurrence of mycotoxins by country (number of samples for specific mycotoxin combinations)

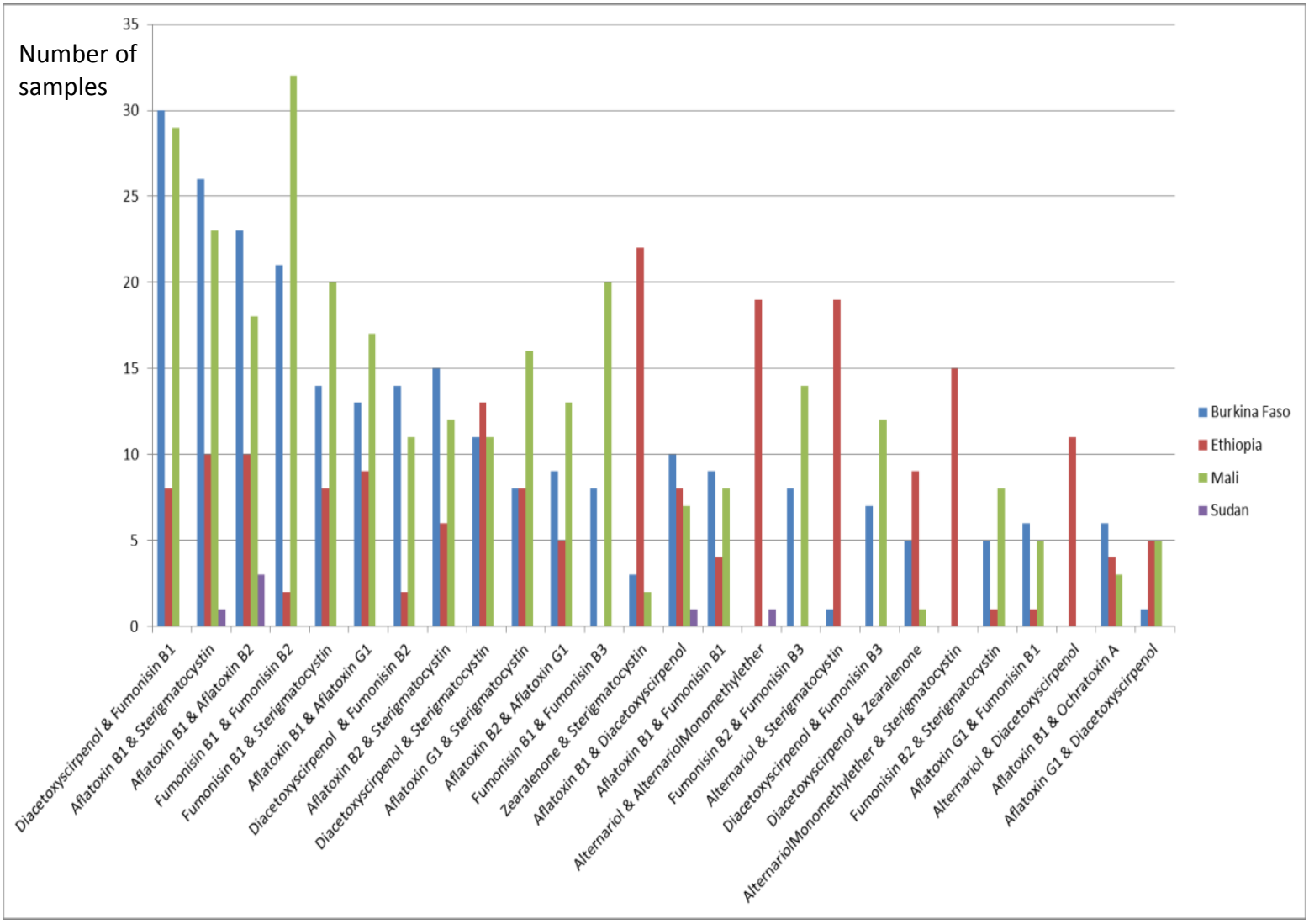

Table 2: Identification of high risk practices and possible intervention points observed in the countries

Production step	High risk practice	Low risk practice
Seeds and varieties		
Sourcing	Own seeds with no quality control	Certified seeds
Varieties type	High yielding non resistant varieties	Local varieties; drought-resistant; heat-tolerant, insect-resistant and striga resistant sorghum varieties
Varieties (color)	White	High tannin red genotypes seems to be associated to higher resistance to fungal infestation
Field activities		
Land preparation	No cleaning of past residues of crops; Conservation tillage	Removing all crop residue from past crop & burning; proper clearing of weeds
Plantation density	High rate of seeding leads to conducive microclimate for fungal development;	Increase spacing when seeding
Irrigation	Exposure to water stress leads to higher risk of mycotoxin contamination	Use irrigation to reduced drought risk; and reduce stress in plants
Association	Association with crops that also support mycotoxin growth; high planting density	
Rotation	No rotation	Using crop rotation especially with crops that do not support mycotoxin producing fungal growth eg. soybean, cassava, sweet potato, potato
Use of agro-chemicals		
Fertilization	Nutritional stress leads to higher risk of mycotoxin contamination	Optimal levels of fertilization are achieved
Fungicide treatment	Infestation with fungal pathogens, no fungal control	Use of multiple methods to control fungal pathogens, resistant varieties, possible use of fungicide, biocontrol
Insecticide treatment	High insect infestation	insect-resistant sorghum varieties, insect control in field especially stalkborers and coleoptera
Herbicide treatment	Leaving weeds, leading to microclimate that is conducive to fungi	Controlling weeds – with herbicide, mechanically or manually
General climatic conditions	Heat and wind facilitate fungal development and propagation of spores; also heat factor for mycotoxin development	No heat or climatic stress – too much, too little rain
Harvest		
Climatic conditions	Harvesting at high grain moisture content or during rainy period	During dry period
Timing	Delays during harvesting (due to labour constraints, other priorities) leading to moisture increase, insect & fungal infestation	Rapid harvesting of sorghum at around 21% grain moisture and transport out of the field

Production step	High risk practice	Low risk practice
Postharvest		
Drying after harvest	Long drying periods and grains left in the field in piles; Cutting plants and leaving on the soil facilitates exposure to fungal spores	Drying of harvested plants or panicles outside the field on clean plastic sheet or other method off the ground
Storage immediately after harvest	Immediate threshing and storage in poorly ventilated bags, like polypropylene bags with high humidity	Storage outside the field on drying platforms to facilitate drying, storage over kitchen fire inside or outside the house
Threshing	Use of machines or mortar which can bless the grain so that fungal spores can enter	Hand-threshing, although this might not be feasible due to time constraint
Winnowing	No cleaning after harvest	Use winnowing to clean grains; can be mechanized which makes it more efficient
Drying after winnowing	Long drying periods in unclean places, on the ground with moisture influx	Dry grains to below 12.5%grain moisture for safe storage, use of storage crib
Sorting	No sorting	Sorting out of damaged, discoloured, shrivelled, germinated and undersized grains (low weight, small size)
Destination for sorted grains	Give to animals or eat themselves, used for beer-brewing or to make processed products where defects can't be seen	Thrown away or burnt; biodiesel; other means of taking out of food chain
Storage and storage management		
Storage form (grain/ panicle)	Storage as panicles without proper ventilation might increase risk of fungal contamination	Good drying and moisture level below 12.5% for storage
Storage location	Mixing old and new stocks; Old store that is badly maintained	Clean store of old crop residue and dust prior to new crop storage; repair all damage to the store making sure roof is watertight
Storage type	Polypropylene bags that leave little aeration; Clay storage structures have been associated with higher fungal contamination and resultant mycotoxin	Made from natural material to facilitate aeration; new, clean jute bags
Moisture content	Store humid grains higher than 12.5%, use traditional method for determining grain moisture	Use grain moisture meter to determine moisture in grains
Moisture influx	Moisture influx due to rain, bad storage structure, temperature differences inside/outside	Keeping grains dry and well aerated
Changing storage structure	Leaving grains for long time without control of conditions	Change store, do sorting, drying and control of conditions when changing storage structure; Control of Grain moisture, if necessary dry to get safe storage levels
Pest, insects and fungal management		

Production step	High risk practice	Low risk practice
Insect infestation	No insect control – they are main vector for fungal spores	Control of insect infestation from field and in store
Insecticide	Using insecticides recommended for other crops eg. Cotton/cocoa etc.	Use of storage insecticides at recommended dose and sufficient waiting period
Botanicals (plant based pesticides)/ ash/sand etc.	Botanicals that are not dry and increase moisture in the stored goods;	Botanicals usually less effective than insecticides, but some have shown in-vitro effect on fungal growth
Other pest infestation	Rat and bird damage from the field to the store increases risk of mycotoxin contamination	Control of other pests and clean storage environment
Fungal infection	Fungal infestation highly correlated with mycotoxin infestation	Do everything possible to control fungal infestation; dry and clean