RUFORUM Working Document Series (ISSN 1607-9345) No. 14 (2): 771 - 779.
Available from *http://repository.ruforum.org*

Research Application Summary

The challenge of mycotoxin contamination to Indigenous chicken production in Western Kenya

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Abstract

Mycotoxins are secondary metabolites of fungi commonly present in the environment. They grow under favorable conditions on extensive variety of substrates in the form of fungi mycotoxin contamination which present risk to crops, livestock and human health at large. Presence of aflatoxin in livestock feedstuff affect performance and productivity of animals and man if consumed beyond permissible levels, posing potential risks to animals and indirectly to human health because of toxic residues contained in animal products. Symptoms of negative effects include drop in general animal productivity, increased susceptibility to disease, chronic damage to vital organs and decreased reproductive performance. Risks of these toxins in animal feeds can be controlled in either pre- or post-harvest stages of feed processing. Main strategies for prevention at pre-harvest stage include proper agronomic practices, use of resistant varieties, application of nontoxigenic fungal strains, minimizing both insect and mechanical damage; while post-harvest approaches involve drying and cleaning ofcommodities, storage in facilities that provide protection from excessive moisture, useof pesticides and other appropriate antifungal agents and protection from rodents and insects. At policy level, regulatory authorities need to take steps that address the issue of aflatoxin contamination to safeguard consumers and protect livestock, especially in the poultry industry. Additionally, quality control strategies should be implemented and efforts to safeguard food sources and utilization enhanced for security, especially in rural areas of developing countries.

Key words: Aflatoxin, food safety, indigenous chicken, livestock feed, mycotoxin

Résumé

Les mycotoxines sont des métabolites secondaires des champignons souvent rencontrés dans l'environnement. Elles se développent dans des conditions favorables sur une grande variété de substrats sous la forme de contamination mycotoxines des champignons qui représente des risques pour les cultures, le bétail et la santé humaine. La présence d'aflatoxine dans les aliments du bétail affecte les performances et la productivité des animaux et aussi l'homme si elle est consommée au-delà des doses normales, ce qui présente des risques potentiels pour les animaux et indirectement pour la santé humaine en raison des résidus toxiques contenus dans les denrées d'origine animale. Les symptômes des effets négatifs incluent une baisse générale de la productivité animale, une sensibilité accrue aux maladies, des dommages chroniques aux organes vitaux et une diminution de performance reproductive. Les risques de ces toxines dans les aliments pour animaux peuvent être contrôlés au cours des stages de pré ou post récolte de la production de provendes. Les principales stratégies de prévention au stade pré-récolte comprennent les pratiques agricoles appropriées, l'utilisation de variétés résistantes, l'emploi de souches fongiques non toxiques, la réduction des dommages aux insectes et aux dommages mécaniques; tandis que les approches post-récolte comprennent le séchage et le nettoyage des produits, le stockage dans des dispositifs qui protègent contre l'humidité excessive, l'utilisation de pesticides et d'autres antifongiques appropriés et la protection contre les rongeurs et les insectes. Au niveau des politiques, les autorités en charge de la réglementation doivent prendre des mesures pour remédier à la question de la contamination par les aflatoxines afin de garantir la sécurité des consommateurs et de protéger le bétail, en particulier dans l'industrie de la volaille. En outre, des stratégies de contrôle de qualité devraient être mises en œuvre et les efforts visant à protéger les sources d'aliments et leur utilisation accrue pour la sécurité, en particulier dans les zones rurales des pays en développement.

Mots clés: Aflatoxine, sécurité alimentaire, poulet indigène, aliments du bétail, mycotoxine

Introduction

Quality of food and feed can be considered as intricacies that determine value or acceptability for consumption. "Food/feed safety" implies absence or acceptable and safe levels of contaminants, adulterants, naturally occurring toxins or any other substance that may make food injurious to health on an acute or chronic basis. Nutritional status, health, physical and mental faculties depend on food/feed eaten and form of presentation. Access to good quality food/feed has been man's main endeavour for time immemorial and safety is a basic requirement for quality. The World Food Summit of 1996 defined food security as "… existing when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life," (FAO, 1996). In the ever changing world, food safety and security remains one of the basic human requirements. Developing countries experience problems of growing population, land fragmentation, urbanization, and more recently, lack of resources to deal with pre- and post- harvest losses in food/feed, among other challenges. The major contributing factor to the latter problem is environment and food handling hygiene. The end result is stressed food systems that adversely affect quality and safety of supplies, leaving consumers exposed to a wide range of potential food quality and safety risks. Estimation of socio-economic consequences of unsafe or contaminated food involves considerations such as value of crops and animal products spoiled or destroyed as a result of such contamination, value of rejections/ detentions in the export trade, medical treatment costs and loss of output or earnings resulting from morbidity, disability or premature death. Death or disability of the wage-earner resulting from contaminated food may have disastrous consequences for quality of life of survivors. Governments must take necessary steps through national food security policies, systems and programs to ensure that food quality and safety considerations form an integral part of food security system and plans. Quality and safety of food and feed have to be ensured throughout production, handling, processing, storage and distribution, preparation and consumption chain. This is a multi-sectoral activity whose objectives cannot be reached without active co-operation of producers, traders, industry, governments, scientific community as well as consumers in general. Implementation of control mechanisms throughout the chain lead to improved quality and safety, increased competitiveness as well as reduction in cost of production and wastage.

The basis of this review is a survey conducted in Western Region of Kenya on feed quality and safety in relation to mycotoxin/aflatoxin contamination, especially as they relate to indigenous chicken production. The region is characterised by high poverty levels, adverse effects of HIV/AIDS (leaving orphans and widows very vulnerable) and need for constant external support and provisions. Additionally, young members of the society have moved to cities with hopes for better sustenance. Interventions from organizations such as Program for Agriculture and Livelihoods in Western Communities (PALWECO), Western Kenya Community Driven Development and Flood Mitigation Project (WKCDD/FMP), Kenya Agricultural and Livestock Research Organization (KALRO) in the region with efforts to empower communities, increase production levels and alleviate poverty have had marginal results.

Mycotoxins

Mycotoxin producing fungi can occur in all agricultural commodities under appropriate field or storage conditions throughout the animal feed supply chain (Bryden, 2012). All feed stuffs are susceptible to contamination by mycotoxins and this is not restricted to any component of feed. The level of contamination varies with location and reflects different agronomic practices and climatic conditions. This is usually dictated by the most prevalent mycotoxigenic fungi present in a farming system (Wicklow, 1995; Bryden, 2009). These microbiological and chemical hazards pose great concern to safe utilization of food and feed stuffs.

Among chemical hazards, the contamination of food and feed by mycotoxins (toxic metabolites of fungi), fishery products by phycotoxins (toxins produced by algae) and edible plant species by their plant toxins have been recently characterized by the World Health Organization (WHO) as significant sources of food-borne illnesses (WHO, 2002). Of the three categories of natural toxins, greater attention has been directed to mycotoxins (Table 1).

The major problem associated with mycotoxin contaminated animal feed is not acute disease episodes but low level toxin ingestion which may cause an array of metabolic disturbances resulting in poor performance and productivity. In studies with pigs and poultry, it has been shown that low level of mycotoxin intake can result in reduced feed intake, poor growth rate, lower egg production, changes in carcass quality, reduced fertility and hatchability of eggs and immune-suppression (Bryden *et al.,* 1980; Burditt *et.al.*, 1983; van Heugten, 2001). It is recognized that mycotoxins constitute a significant problem for the animal feed industry and risk to feed supply security. Acute toxicity occurs when high dosage is ingested at single intake while chronic toxicity results from exposure to low dosage over a long period. Regardless of the form of toxicity, mycotoxicoses is an issue of health concern.

Table 1: Toxigenic fungi and associated mycotoxins

Fungal species	**Mycotoxin**
Aspergillus flavus; A. parasiticus	Aflatoxins
A. flavus	Cyclopiazonic acid
A. ochraceus; A. carbonarius; Penicillium verrucosum	Ochratoxin A
P. citrinum; P. expansum	Citrinin
Fusarium sporotrichioides; F. poae	T-2 toxin
F. sporotrichioides; F. poae	Diacetoxyscirpenol
F. culmorum; F. graminearum	Deoxynivalenol
F. culmorum; F. graminearum	Zearalenone
F. verticillioides; F. proliferatum	Fumonisins
Alternaria alternate	Tenuazonic acid
Claviceps purpurea	Ergot alkaloids

Source: Bryden, 2012

Severity of mycotoxiosis depends on mycotoxin type, animal health status, stage of production and dose ingested. Some types damage organs directly (e.g. liver, rumen), whilst others impair reproduction or cause cancer (Bryden, 2012). Physical effects range from performance loss to mortality. Different mycotoxins can interact to exacerbate effect and some are known to suppress immune function (Fink-Gremmels, 2008). Many human diseases, especially carcinogenic, teratogenic, hepatic, and gastrointestinal ones, have been found linked with ingestion of mycotoxin-contaminated products (Fung and Clark, 2004; Shephard, 2008). Lewis *et al.* (2005) reported 317 cases of aflatoxicosis in humans in Kenya with a mortality rate of 68% in 2004.

Mycotoxin contamination negatively impacts food safety globally. Awareness of their serious effects on human and animal as well as economic constraints has led to establishment of regulations on acceptable limits in both in food and feed to safeguard human health as well as the economic interests of producers, traders and consumers (van Egmond, 2013). Setting mycotoxin regulations is a multifaceted activity involving numerous factors and sectors. Overall, there are a number of approaches that can be taken to minimize contamination in animal feed. They all involve prevention of mycotoxigenic fungi growth, which in turn, reduce or eliminate mycotoxins from contaminated commodities, especially feeds.

Mycotoxin risks in livestock feed

Quality of feed supplied is essential in all animal production systems and any aspect that affects safety and security consequently impacts negatively on production. Feed spoilage by fungi presents a formidable challenge, especially on safety and security along the production – consumption chain. It may result from harvesting, handling, storage, processing and presentation, consequently reducing palatability and nutritive value (Christensen, 1974). Moreover, affected commodity may become contaminated with toxic secondary fungal metabolites, with mycotoxicoses being the resulting syndrome (Richard, 2007). Biological reactions following ingestion of one or a combination of mycotoxins vary from acute, overt disease with high morbidity and death to chronic, insidious disorders with reduced animal productivity (Bryden, 2012). Fortunately, mycotoxin contamination levels in animal feedstuffs are usually not high enough to cause an overt disease but may result in economic loss through clinically obscure changes in growth, production and immunosuppression (Hamilton, 1982). Moretti (2013) emphasized the importance of knowledge of biodiversity of toxigenic fungi to better understand factors that contribute to mycotoxin production, assessment of risks posed by mycotoxigenic fungi, and reduction of mycotoxin contamination in feed and food crops. The mycotoxigenic fungi involved in food and feed chain mainly belong to the *Aspergillus, Penicillium, Fusarium* and *Alternaria* genera. Species of *A. flavus, A. parasiticus* and *A. nomius* (Table 1) are major fungi producers of aflatoxins metabolites, highly toxic compounds of concern in food safety. *A. flavus* also produces other mycotoxins such as cyclopiazonic acid (Ashiq, 2015). During harvesting, handling, storage, and distribution, agricultural commodities are subjected to infection by toxigenic molds, which may cause spoilage and produce mycotoxins. Fungal contamination of various food commodities with consequentexposure of the community to mycotoxins is a hazard that potentially exists depending on environmental factors, crop health, and soil conditions. Mycotoxins have serious consequences due to substantial economic loss and risk to health. A number of them are known to remain stable under food processing conditions and may be present in the final product (Mati´c *et al*., 2008; Matumba *et al.*, 2014).

Common predisposing practices among rural folk include placing harvested commodities directly on the ground, drying on the ground, leaving them overnight on the ground, among other handling practices. These expose products to sources of contamination or make them more susceptible. During the baseline survey observed feed types included maize, millet, sorghum, sugar, maize bran, pollard, wheat bran, maize germ, roots and tubers. These form over 75% of poultry feed. Other popular ones include soya meal, peanuts, beans, peas, oil cakes, fish, maggots, termites, worms and insects. Vitamins are obtained from green grass, vegetables and other plants. Many vitamins and nutrients are destroyed if the feed is stored too long or under sub-optimal conditions, e.g. high humidity and heat. Lack of resources and infrastructure for post-harvest handling, storage and processing can lead to fast deterioration in quality, hence unavoidable contamination and eventual loss. Pre-harvest practices, time of harvesting, handling of produce during harvesting, moisture levels at harvesting, transportation, marketing and processing; insect damage may all contribute to mycotoxin contamination. Duration of storage, hot and humid conditions are some of the most important factors that support fungal proliferation and mycotoxin formation (Atanda *et al.*, 2013). Likewise, the environmental hygiene where the animals are raised can contribute to contamination.

Possible intervention strategies include good agricultural practices (GAP) such as early harvesting, proper drying, sanitation, proper storage and insect management among others. Other possible interventions include biological control, chemical control, decontamination, breeding for resistance as well as surveillance and awareness creation. Therefore, there is need for efficient, cost-effective sampling and analytical methods that can be used for detection analysis of mycotoxins in produce in developing countries.

Mycotoxins and indigenous chicken production

Indigenous chicken is a name used to refer to chicken that are adapted to harsh environmental conditions, including extensive, small-scale village, free range and organic production systems. Other references include traditional, scavenging, backyard, village, local or family chicken. In developed nations, the term “free range” is mainly used as a marketing term rather than a husbandry term, meaning something on the order of, “low stocking density,” “pasture-raised,” “grass-fed,” “old-fashioned,” “humanely raised.” Production is characterized by poor housing, flock size ranging from 1-50, minimal veterinary services, with traditional treatment remedies being offered, birds scavenging with occasional supplementation, minimal attention given to birds, high mortality rates, extensive broody periods and un-controlled breeding. The objective of indigenous chicken production is mainly for subsistence where women and children play dominant roles (Okito*i et al*., 2007).

Farmers can earn more from indigenous chickens than exotic ones through premium pricing strategies; currently the price of an indigenous chicken egg is Ksh.15.00 while that of exotic ones goes for Ksh. 10.00. A kilogram of indigenous chicken meat costs Ksh. 400.00 – 600.00 while exotic poultry meat costs Ksh. 300.00 a kilogram. This premium pricing is due to good taste and flavor of their meat, an advantage to low-income families. Additional advantages are that they are adapted to all climatic zones in the country, hardiness, minimal space requirement and monitoring, among others. They also cost less to maintain and feed.

A reason for minimal returns to farmers is that indigenous chickens are left to scavenge for feed; thus take long to improve their quality and weight. Chicks are also left to scavenge and compete for feed with adult birds, hence take long to mature. Many farmers do not provide these birds with adequate and clean water. Feed are thrown on the ground instead of clean and hygienic feeders, predisposing them to consuming contaminated feeds. The complex diet of poultry, consisting of grains, vegetation, and worms, can be a source of diverse mixture of mycotoxins that contaminate individual feed components (Smith and Korosteleva, 2012). Performance of birds is adversely affected by ingestion of mycotoxin-contaminated feedstuff and such feed are usually fed to animals, causing illness, decrease growth rate and impaired performance (Smith *et al.,* 1992; Jones *et al.*, 1994). Methods of presentation (anywhere on the ground) as well as living conditions (hot, damp, dark and un-hygienic) exacerbate contamination potential.

Conclusions and recommendations

Rearing of indigenous chicken among rural household has potential of empowering women and youth who are the majority among communities in Western Kenya. However, consumption of mycotoxin-contaminated feed and food adversely affects performance of livestock and human with challenges such as decreased performance and productivity, health risks as well as economic losses. Necessity of raising awareness on occurrence of mycotoxins in food and feed commodities, especially prosducers, remains paramount. Appropriate agricultural practices should be followed and conditions for harvesting, storage, handling, and processing improved to achieve desired outcomes. Overall goal should be improved nutrition, health and incomes of the poor by sustainably increasing livestock productivity and marketing and consumption of animal-source foods. This can be achieved by introducing new location-appropriate technologies, improving management practices, skills, knowledge, capacity and access to and quality of inputs across livestock value chains, and by supporting development of a friendly environmental policy fostering sustainable intensification and increased profitability of smallholder livestock systems .

Acknowledgement

This project was funded by the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) Grant Number: RU 2015 GRG-115. This paper is a contribution to the 2016 Fifth African Higher Education Week and RUFORUM Biennial Conference.

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