Stemming Aflatoxin in the Groundnut Chain in Sub-Saharan Africa

Authors: ¹Limbikani Matumba, ²Kerstin Hell, ³Benoit Gnonlofin, ⁴Mweshi Mukanga, and ⁵Henry Njapau

Background

Groundnut (Arachis hypogaea L.), a tropical food crop is a rich source of multiple nutrients with associated health benefits. Among others, consumption of good quality groundnuts helps to reduce the risk of cancer and obesity, boosts memory, combats depression, prevents several cardiovascular disorders, and treats hemophilia and other blood related disorders (Sanders et al., 2000; Ros, 2010; Vinson and Cai, 2012; Allen, 2008; King et al., 2008). However, the presence of aflatoxins, poisonous and cancer-causing compounds that are produced by certain pathogenic molds (mainly Aspergillus flavus and A. parasiticus) compromise the health safety and nutritional value of the crop thereby affecting the marketability of groundnuts. This policy brief has been specifically prepared to highlight the importance of aflatoxins on human health and trade in Sub-Saharan Africa (SSA). It contextualizes, (i) the preharvest and post-harvest factors that influence the proliferation of molds and aflatoxin contamination in groundnuts in the SSA region, (ii) discusses feasible prevention and management strategies and (iii) presents recommendations.
Consumption of aflatoxin contaminated food may result in acute or chronic aflatoxicosis (aflatoxin poisoning). Acute aflatoxicosis is a rare event that results from the exposure to moderate to high levels of aflatoxins and is characterized by hemorrhagic necrosis of the liver, bile duct proliferation, edema, lethargy, blindness and death. Only a few incidents of acute aflatoxicosis have been documented (Reddy and Raghavender, 2007; Probst et al 2007; CAST, 2003). In tropical regions, populations are chronically exposed to low to moderate levels of aflatoxins. The effects of this chronic exposure is usually subclinical and difficult to recognize, but have been related to far reaching health effects, such as liver cancer.

Existing data provide sufficient evidence of carcinogenicity of aflatoxins in humans (IARC, 1982). Aflatoxin B1, the most important analog of aflatoxin acts synergistically with the hepatitis B virus in causing hepatocellular carcinoma (HCC) (liver cancer) (Kew, 2013). It is estimated that aflatoxin B1 play a causative role in 5–28% of all global HCC cases of which approximately 40% prevail in SSA (Liu and Wu, 2010).

Chronic exposure to aflatoxins compromises immunity and decreases resistance against many diseases including malaria, tuberculosis and other opportunistic infections. Moreover, chronic exposure to aflatoxins has been found to reduce vaccine and therapeutic efficacy in various animals (Oswald et al., 2005; Ghoneimy et al., 2000; Venturini et al., 1990; Choudhury et al., 1998; Singh, et al., 1997) and possibly in humans. Worse still aflatoxins have been proven to be transferable across the porcine placenta and similarly affect the unborn fetus (Pier et al., 1985). More importantly, there is substantial evidence that aflatoxins increase the rate of progression from HIV infection to AIDS (Jiang et al., 2005; Jolly et al., 2013; Jolly, 2014). This observation is particularly important in SSA considering the high prevalence of HIV (UNAIDS, 2015). Further health effects are presented in Table 1.

### Table 1: Further effects of aflatoxins on human and animal health

<table>
<thead>
<tr>
<th>Health effect</th>
<th>Reference</th>
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<tbody>
<tr>
<td>Impaired digestion and reduced nutrient absorption</td>
<td>Yunus et al., 2011</td>
</tr>
<tr>
<td>Reduced sperm count and infertility; neonatal defects; Low birth weight</td>
<td>Shuaib, et al., 2010; Wangikar et al., 2005</td>
</tr>
<tr>
<td>Liver, kidney, and spleen enlargement, fatty liver disease Kidney inflammation leading to kidney failure</td>
<td>Quezada et al., 2000; Merkley et al., 1987</td>
</tr>
<tr>
<td>Depression and behavioral abnormalities</td>
<td>Kihara et al., 2000; Williams, et al., 2004</td>
</tr>
<tr>
<td>Growth faltering/stunting in children</td>
<td>Gong et al., 2002; Turner, et al., 2007</td>
</tr>
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</table>

Given the above facts, it is not surprising that Williams, et al. (2004) argue that in spite of aflatoxin not being listed among the World Health Organization’s (WHO) ten important health risk factors contributing to the burden of disease in developing countries [as measured by disability-adjusted life years (DALYs)], aflatoxins enhances the six top risk factors as above. Consequently aflatoxin accounts for 44% of the DALYs in countries where a short lifespan is prevalent. Moreover it has been established through serum assessment that poverty significantly relates to aflatoxin exposure (Leroy et al.2016).
Aflatoxin prevalence in groundnuts in SSA and the associated trade and economic impacts (The associated trade and economic impact of aflatoxin prevalence in groundnuts in SSA)

Sub-Saharan Africa (SSA) lies within the tropics where conditions favour mold growth and aflatoxin contamination (CAST, 2003). To protect consumers from the harmful effects of aflatoxins, most governments have established regulatory limits for the toxin in food, including groundnuts (Table 2). The enforcement of regulations in developing countries is challenged by several factors including the prevalence of subsistence farming and the lack of decentralized analytical facilities (Matumba et al., 2015a; Shephard, 2003). In spite of this, groundnuts from this region are successfully exported to countries with stringent aflatoxin regulatory limits after careful hand sorting. This process of producing ‘aflatoxin free’ lots for export, produces grade-outs with high levels of aflatoxin which are sold in the local market (Matumba et al., 2015b), or processed into edible oil and animal feed.

Table 2: Total Aflatoxin maximum tolerable limits for groundnuts in selected Countries and Regions

<table>
<thead>
<tr>
<th>Country or region</th>
<th>Aflatoxin maximum tolerable limit (parts per billion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia and New Zealand</td>
<td>15</td>
</tr>
<tr>
<td>Canada</td>
<td>15</td>
</tr>
<tr>
<td>Common Market for Eastern and Southern Africa (COMESA) countries</td>
<td>10*</td>
</tr>
<tr>
<td>Europe Union (EU)</td>
<td>4</td>
</tr>
<tr>
<td>Mozambique</td>
<td>10</td>
</tr>
<tr>
<td>South Africa</td>
<td>10</td>
</tr>
<tr>
<td>Southeast Europe</td>
<td>10</td>
</tr>
<tr>
<td>Tanzania</td>
<td>10</td>
</tr>
<tr>
<td>United States</td>
<td>20</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td></td>
</tr>
</tbody>
</table>

Source: Own compilation; * Proposed harmonized regulation

It is worth mentioning that it is difficult to evaluate the economic impact of aflatoxins in groundnuts in SSA. One difficulty lies in quantifying the degree of the problem due lack of comprehensive surveillance data. Another constraining factor is that aflatoxin contamination in groundnuts has a different effect on trade within SSA countries compared to trade from Africa to developed countries. It can generally be argued that within SSA, with the exception of moderately developed countries such as South Africa, aflatoxin contamination has no effect on trade since most exchanges are unregulated. This makes the management of aflatoxin difficult as contaminated produce still finds itself on the market, and consequently farmers may not find it economical to employ aflatoxin control and management measures. Nonetheless there is growing acceptance by African governments that aflatoxin contamination in groundnuts can result in economic losses through rejection of the crop by developed countries markets, increased human health-care costs, veterinary expenses and loss of livelihoods in the groundnuts producing communities.

Aflatoxin control and management strategies in groundnuts

Groundnuts can be contaminated with aflatoxin at various stages: in the field, during harvesting, drying, in storage and during processing. Fortunately, extensive research has been carried out and several control and management strategies have been developed and do exist. These are: good agricultural practice (crop rotation, timely planting, timely harvesting, proper moisture control, improved storage); use of agro-ecologically adapted varieties; proper disease and pest management including use of bio-control agents; breeding for resistance, and processing (Table 3).
### Table 3: Total Aflatoxin maximum tolerable limits for groundnuts in selected Countries and Regions

#### Explanation

<table>
<thead>
<tr>
<th>Pre-harvest</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Planting</td>
<td>Allows the groundnuts to mature before end of rains preventing Dorner et al., 1989</td>
</tr>
<tr>
<td>Use of agro ecologically adapted varieties</td>
<td>Matches variety with an agro-ecology and allow the groundnuts to mature before moisture stress Dorner et al., 1989</td>
</tr>
<tr>
<td>Crop rotation</td>
<td>Helps reduce toxigenic fungal population Jaime-Garcia and Cotty, 2010</td>
</tr>
<tr>
<td>Proper spacing</td>
<td>Distantly spaced plants increase aphid population and consequently increase risk of aflatoxin occurrence. Similarly, highly dense planting leads to competition for nutrient and moisture and result in plants with less vigor that cannot resist fungal infestation. A’brook, 1968</td>
</tr>
<tr>
<td>Adequate soil nutrient supply</td>
<td>Promote plant vigour and consequently withstand disease Torres et al., 2014</td>
</tr>
<tr>
<td>Use of pest and disease tolerant varieties</td>
<td>Promote plant vigour and consequently withstand disease Torres et al., 2014</td>
</tr>
<tr>
<td>Proper weed management</td>
<td>Excessive weed growth may deplete available soil nutrients and moisture and increase risk of aflatoxin contamination Hell and Mutegi, 2011</td>
</tr>
</tbody>
</table>

#### Pest and Disease Management

| Biological control | Non toxigenic fungi (Aspergillus and Trichoderma), bacteria or yeasts reduce aflatoxigenic fungi populations hence the levels of aflatoxin Bandyopadhyay et al., 2003; Dorner et al., 2003; Kishore et al., 2001; Srilakshmi et al., 2001; Yan et al., 2010 |

#### Harvesting

| Timely harvesting | Early harvest under high aflatoxin risk conditions results in lower aflatoxin concentrations. However, under low aflatoxin risk conditions crops could be left longer to realize higher potential yield and better seed grades Rachaputi et al., 2002 |
| Avoiding mechanical damage of the pods | Minimum damage of shells during harvesting of the crop reduces significantly mould contamination. Widstrom et al., 1979 |

#### Post-harvest handling

| Kernel moisture control | Rapidly drying groundnuts to safe moisture levels reduces chances for mould proliferation and aflatoxin contamination Dorner, 2008 |
| Kernel sizing and sorting Blanching Storage | Careful removal of mould diseased kennel and blanching significantly reduces aflatoxin levels Galvez, et al., 2003 |
| | Dry well-ventilated store room with adequate air circulation or hermetic storage with oxygen-absorbing sachet or injected carbon dioxide Villers 2014 |
Adoption of these, sometimes labor intensive, techniques would require incentives. The incentives include higher prices for “aflatoxin-free” (i.e., meeting standards stipulated in Table 2) hence better quality groundnuts. The sustainability of production processes that result in aflatoxin-free groundnuts will be driven by increased public awareness of the health risks associated with consuming mycotoxin contaminated food, including groundnuts. Moreover there is need to find profitable alternative uses for contaminated groundnuts that are sorted out in order to pull them away from the human food chain. One viable alternative is the extraction of oil from contaminated groundnuts since only a small fraction of aflatoxin is carried into the edible vegetable oil due to the toxin’s lipophobicity. Most of the aflatoxin remains in the groundnut cake. Further purification steps are required to completely eliminate the toxins from the oil. Another viable option is the use of moderately contaminated nuts as animal feed. For instance, the United States Food and Drug Administration (FDA) has provided guidance on tolerable aflatoxin levels in feed for various livestock categories (Table 4).

### Table 4: Total Aflatoxin maximum tolerable limits for groundnuts in selected Countries and Regions

<table>
<thead>
<tr>
<th>Aflatoxin Level (parts per billion)</th>
<th>Livestock category/use</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 ppb</td>
<td>Feed for dairy animals; for animal species or uses not specified below, or when the intended use is not known.</td>
</tr>
<tr>
<td>20 ppb</td>
<td>Feed for immature animals (independent of species).</td>
</tr>
<tr>
<td>100 ppb</td>
<td>Feed for breeding beef cattle, breeding swine or mature poultry (e.g. laying hens).</td>
</tr>
<tr>
<td>200 ppb</td>
<td>Feed for finishing swine (100 pounds or more).</td>
</tr>
<tr>
<td>300 ppb</td>
<td>Feed for finishing beef cattle (i.e., feedlot cattle).</td>
</tr>
</tbody>
</table>
From the foregoing, the aflatoxin exposure scenario in Sub-Saharan African (SSA) is unlikely to change unless the region develop and adopts policies that drive the reduction of aflatoxin occurrence in various foodstuffs. This viewpoint was equally recognized by the FANRPAN Regional Policy Dialogue held in Lusaka Zambia (28th August 2015).

In this regard, the following policy recommendations are advanced in order to reduce aflatoxins in the groundnuts value chains in SSA:

- **Augment farmers’ knowledge on aflatoxin issues holistically placing emphasis on both domestic and export requirements.** Well informed farmers are more likely to take care of the whole production chain, thus making local food safe and exportation much easier. Particular emphasis should be on safeguarding rural farming families and finding marketing opportunities.

- **Embrace an integrated aflatoxin management system by utilizing proven technologies such as the use of adapted varieties, moisture conservation, nutritional stress reduction, integrated pest and disease management, early planting, timely harvesting and moisture control during storage, and sorting.**

- **Encourage and promote the participation of entrepreneurs along the groundnuts value chain with a specific bias towards activities that reduce aflatoxin contamination and improve market access.**

- **Facilitate national or regional research on the relationship between aflatoxin in the context of health-nutrition and agriculture.** This would enhance the recognition and understanding of diseases associated with chronic and acute exposure to aflatoxins among health and agriculture professionals including traders.

- **Ensure the availability of affordable, easy to use and reliable aflatoxin diagnostic tools (such as rapid test kits) to the groundnuts processors, vendors and accredited facilities support to food processing industries, regulators and exporters.**

- **Increase support to research and development on aflatoxin control, taking into account the traditional/indigenous knowledge.** Such Research and Development (R&D) activities should include understanding the effects of aflatoxin on non-hepatotoxic disorders and the synergistic/additive effects of other mycotoxins.
PAEPARD CRF Project: Stemming Aflatoxin pre- and post-harvest waste in the groundnut value chain (GnVC) in Malawi and Zambia to improve food and nutrition security in the smallholder farming families

Funded by the Platform for African—European Partnership in Agriculture and Rural Development (PAEPARD) through the competitive research fund.

Project Summary
Groundnuts form the basis for food and nutrition security for the majority of the smallholder farmers and are a vital component in the livelihoods of rural families. The challenge is that the groundnuts of these smallholder farmers are prone to Aflatoxin contamination. The contamination can occur any time from pre-harvest to post-harvest and has enormous health and economic consequence. Investing in pre- and post-harvest loss research, technical advice and policy advocacy to reduce food losses could significantly increase the food and nutrition security.

The project aims to reduce pre and post-harvest waste in the groundnut value chain (GnVC) and thereby increase food and nutrition security of smallholder farmers in the focal countries. The project intervenes at three levels:

- Based on the applied research and analysis of major constraints related GnVC, promising pre- and post-harvest practices and technologies are assessed, validated and further developed through participative evaluation in selected rural households
- The successfully tested practices are documented, appropriate dissemination tools and methodologies are elaborated, and farmer capacities are built; and
- Based on the evidence gained from the validation of pre- and post-harvest practices and technologies, advocacy and policy dialogues are conducted through multi-stakeholder platforms at the local, national and regional levels with the aim of strengthening these aspects in policies and regulatory frameworks.
- The project targets smallholder and poor farm families with specific focus on women in Malawi and Zambia.

The Platform for Africa-Europe Partnership in Agricultural Research for Development (PAEPARD) is a 8-year project sponsored by the European Commission (80%) and partners’ own contribution (20%). It is coordinated by the Forum for Agricultural Research in Africa (FARA) since December 2009, and extended until end of 2017. It aims at building joint African-European multi-stakeholder partnerships in agricultural research for development (ARD) contributing to achieving the Millennium Development Goals. On the European side, the partners are AGRINATURA (The European Alliance on Agriculture Knowledge for Development, coordinating the European partners), Europe-Africa-Caribbean-Pacific Liaison Committee (COLEACP) (representing the private sector), CSA (representing the NGOs), (International Centre for development oriented Research in Agriculture (ICRA), specialized in capacity building in ARD, and the Technical Centre for Agricultural and Rural Cooperation (CTA). On the African side and in addition to FARA, the partners are the Pan-African Farmers Forum (PAFO), the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) based in Kampala, and the Food Agriculture Natural Resources and Policy Analysis Network (FANRPAN) based in Pretoria. PAFO involves its members that are the Eastern Africa Farmers Federation (EAFF) based in Nairobi, the Réseaux des Organisations Paysannes et des Producteurs d’Afrique de l’Ouest (ROPPA) based in Ouagadougou, and the Plate-forme Régionale des Organisations Paysannes d’Afrique Centrale (PROPAC) based in Yaoundé. The Southern African Confederation of Agricultural Unions (SACAU) is an associate partner of PAEPARD.

‘Authors’ affiliation and contacts:
1 Lilongwe University of Agriculture and Natural Resources (NRC campus), Food Technology and Nutrition Group, Lilongwe alimbikani@gmail.com; 2 International Institute of Tropical Agriculture, Cotonou, Benin kerstnhell@gmail.com; 3 Catholic University of Eastern Africa, Nairobi, Kenya banjonlonfin74@gmail.com; 4 Zambia Agriculture Research Institute, Chilanga, Zambia mweshi@gmail.com; 5 National Institute for Scientific and Industrial Research, Lusaka, Zambia (hnjapou@hotmail.com)
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About FANRPAN

The Food, Agriculture and Natural Resources Policy Analysis Network (FANRPAN) is an autonomous regional stakeholder driven policy research, analysis and implementation network that was formally established by Ministers of Agriculture from Eastern and Southern Africa in 1997. FANRPAN was born out of the need for comprehensive policies and strategies required to resuscitate agriculture. FANRPAN is mandated to work in all African countries and currently has activities in 17 countries namely Angola, Benin, Botswana, Democratic Republic of Congo, Kenya, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe.

FANRPAN Regional Secretariat
141 Crescent Road, Weavind Park 0184, Private Bag X2087, Silverton 014, Pretoria, South Africa

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