Chapter

Major Contaminants of Peanut and Its Products and their Methods of Management

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Abstract

Peanut (*Arachis hypogeae* L.), Fabaceae, is highly rich in protein (26%). It has popular products such as roasted peanut, peanut butter, and oil. They are vulnerable to many contaminants specified by the Codex Alimentarius, Codex Committee on Contaminants of Food (CCCF), such as biological contaminants, insects, fungi, bacteria, and toxins, which can be byproducts or native contaminants; mycotoxins, which are yard sticks in local and global trade; physical and solid objects (e.g., trash); residues of pesticides and aerial pollutants, such as heavy metals, including lead, copper, nickel, and halogens, etc., from industrial gases and wastes; and industrial byproducts, such as furans and radiation, in addition to the free radicles that arise from rancidity and other metabolic processes. The reactions from and actions taken by the organizations of pertinence are reflected in the setting of maximum acceptable limits (MALs). These include the FAO, WHO, Codex Alimentarius, the European Food Safety Association (EFSA), USA and KSA Food and Drug Administrations, the SSMO (Sudanese Standards & Metrology Organization), etc. However, researchers and governments worldwide are all involved in enormous tedious and fruitful efforts to integrate the management of these contaminants.

Keywords: contaminants, residues, biological, radiant and chemical, management

1. Introduction

Peanut [*Arachis hypogaea* L. (*A. nambyquarae* Hoehne), (*Lathyrus esquirolii* H. Lév.) [1]] is a flowering leguminous crop belonging to the family Fabaceae (Leguminosae).

It has other common names [groundnut, goober (US), pindar (US), and monkey nut (UK)] [2, 3]. This crop is grown in tropical and subtropical regions [4]. Its importance stems from being a good source of protein (an average of 25%) in the panglobal kitchen and a rich source of edible oil as well, in addition to being an essential input for salads, appetizers, etc. The nutritional value of peanut paste and grain includes 21% carbohydrates, and the percentage of vitamins is [6^{-4} B_1 (thiamine); 3^{-4} B_2 (riboflavin); 129^{-4} B_3 (niacin); 18^{-4} B5 (pantothenic acid); 3^{-4} B_6 (5MTHF glucosamine); 246^{-6} B_9 (folate); 66^{-4} E (alpha-tocopherol)]; the dietary fiber has a sizeable share of 9%, and the fat has a lion's share of 48% (7% of it is for saturated fat, and the remainder is for the mono- and polyunsaturated fat) [5]. The mineral content of peanuts contributes well to the recommended daily intake [5]. That is, the reported percentages are as follows: calcium, 62^{-3}; iron, 2^{-3}; magnesium, 184^{-3}; manganese, 2^{-3}; phosphorus, 336^{-3}; potassium, 332^{-3}; and zinc, 33^{-4}, whereas the moisture content percentage is approximately 426^{-5} [5]. The term peanut is not a true nut but is used metaphorically and is a figurative description, as it is treated in Western culinary works such as other used ones such as almonds and walnuts [6].

South America (Argentina, Brazil, Bolivia, Peru, etc.....) is the center of the origin of peanuts [7]. This is the geographic location where the most abundant diversity of peanuts has been reported [7]. However, the top ten producer countries of peanut are China (which produces almost half of the global annual production, with 47 million tons); India, which has 21% of the total global production; Nigeria (which produces 30% of the total African peanut production); Senegal (which is one of the largest peanut exporters and exports most of its production to China); Burma (which has 2 million tons of peanut annual production and ranks fifth); Chad (which is the backbone of its agricultural production, which is mostly exported); the USA (which produced 3.7 million tons in 2021); Indonesia (which contributes 4% of the total international peanut production); Argentina (which produces the top quality peanut in the world known as the golden peanut); and Ghana (which is the first cash crop in the country) [8].

The production of peanuts is better in light-textured soil with good supplementary fertilization [9]. However, the management of pests and diseases is a cornerstone for feasible production. Many pests (including insects, nematodes, weeds, rodents, and birds) attack peanuts during field and postharvest periods. In addition, a number of diseases (fungal, bacterial, virus, etc.). However, infection with *Aspergillus* species is an important concern in peanut production and marketing [10]. Therefore, it is the most important contaminant of this grain crop and has many medical implications as a cause of acute and chronic diseases, including aflatoxicosis and hepatoma, respectively [11]. In addition to being a yard stick for export quality for international markets [11].

Oil is a major product of peanuts. In addition, a number of other products are used internationally and extensively, including peanut butter (paste); roasted nuts; and product formulations in meat, soups, desserts and confections [12]. In addition, there is peanut flour, defatted peanut protein meal, peanut protein concentrate [13], peanut milk and chocolate [14]. However, there are some complications and concerns related to the consumption of peanuts and their products. Others include weaning foods (Khalil, personal communication). These include the following:

1. The sensitivity to peanuts ranges from difficulty in digestion to severe allergies. The term "allergy to peanut" refers to a specific protein, *viz.* immunoglobulin E (IGE) and anaphylatoxins [APTs, release histamine and secretions of mast cells (enhance degranulation)]. Histamine causes dilation of vessels and pulmonary bronchioles (bronchispasm). The symptoms of this allergy include many signs that vary from vomiting to anaphylactic shock [15]. In Canada, it is not allowed to use any nut or nut products in food industry plants, which are labeled "NUT FREE ZONE."

2. Contaminants: These include physical (stones, trash, pieces of glass, debris, etc.).), biological [microbial (fungal and bacterial) and insect (live and parts

of them and their excreta) [11]], chemical [residues (pesticides, radiants, and heavy metals such as lead), byproducts of cooking (furans [16], nitrosamines, nitrates and nitrites [17], and microbial byproducts (mycotoxins) [11]].

The incessant consumption of peanuts is linked to protection from a variety of diseases, including diabetes II [18]; heart and vessel diseases [19]; cancers of the colon, prostate, and breast [20]; osteoporosis and protein hunger [21]; and combating the complications associated with obesity and metabolic syndrome [22].

2. Contaminants of peanut and its products

Peanut (*A. hypogea*) and its products, such as peanut butter, are considered the main input and spinach, respectively, in the panglobal kitchen. The oil, as a major product, is also subjected to contamination by a number of exotic and ordinary, native, and unwanted problematic constituents. That is, the ordinary products include allergens such as immunoglobulin-E (IGE) and the free radicals of catabolized fatty acids such as hydroperoxide and its other products due to decomposition, mainly by heating [23].

2.1 Native and unwanted seed constituents

These are ordinary materials that naturally constitute the raw peanut or the products that arise from the processing of the peanut itself and have conflicting interests with human digestion and health.

2.1.1 Native constituents

These include immunoglobulin-E, Arachis hypogea 2 (Ara h 2), and Ara h 6, [reduced and alkylated in the presence or absence of glutaraldehyde (RAGA)] [24]. These two proteins are specific markers for peanut allergies. Ara h 2 (the most potent of these allergens) is the dominant allergen, and Ara h 6 shares 60% similarity with the former [25]. Other allergens include Ara h 1, Ara h 3, Ara h 8, 2S, 7S, and 11S [26]. Studies on peanut allergies revealed that it affects more than 1% of the developed world population [24]. Peanut 2S albumins (Ara h 2/6) do not respond to or tolerate proteolysis in the gastrointestinal tract (GIT) of patients or at high temperatures. That is, by doing so, they are found to be the most effective in inducing the more unadorn types of peanut allergies [27].

2.1.2 Native constituent byproducts

2.1.2.1 Polyunsaturated fatty acids (PUFAs)

These compounds are more responsive to changes than the mono- and saturated analogs because of the following:

- *Autooxidation*: These enzymes are highly degradative due to their strong response to autooxidation. This sharply reduces their shelf life at ambient temperature [28]. PUFAs degraded at high oil temperatures (150°C/302°F). The byproducts are free radical chains that result in the production of hydroperoxide, which is a complex of secondary products [23].

- *Hydrogenation*: This process results in a small amount of saturated fatty acids from PUFAs. These products include intermediate monounsaturated carbon 20 derivatives [28].

2.1.2.2 Other products

- The roasting of peanuts in dry air at 140–180°C for 5–10 minutes affects the oil quality. That is, it reduces the peroxide value, radical scavenging activity (RSA), and conjugated dienes. Most of the quality indices of oil from roasted peanuts are greater than those of oil from raw seeds [29].

- Byproducts of cooking produce furans [16], nitrosamines, nitrates and nitrites [17], and microbial byproducts mycotoxins [11]. The nitrogen-containing byproducts result from peanut browning [16].

2.2 Management of peanut allergy

Peanut induces unembellished allergies in humans [30, 31]. To date, no cure has been reported for peanut sensitivity [32]. However, mitigation can be achieved through a number of invented methods. These methods include the following

1. Altering the chemical structure of Ara h2 and Ara h6 causes a reduction in the negative impact of peanut allergy therapy (by approximately 100-fold) [33].

2. The subcutaneous injection of CPE (crude peanut extract) showed good results with a low probability of unwanted effects [34].

3. Modification of the allergenic peanut proteins results in low IgE binding and consequently low allergy [34].

4. The use of peroxidase (POD) as a catalyst in tyrosine oxidation leads to reduced allergenic activity of peanut proteins [35].

5. The allergenicity of peanut proteins is reduced by polyphenol oxidase (PPO) [35].

6. Epinephrine treatment by inhalation and injections for moderate and severe peanut allergies, respectively, is recommended [36].

3. Exotic peanut contaminants

3.1 Physical contaminants

3.1.1 Heavy metals

Metals with an atomic number greater than 20 or an atomic density higher than 5 g cm^{-3} were included [37]. They are divided according to their importance to living organisms into two groups: essential, which includes copper (Cu), iron (Fe), manganese (Mn), cobalt (Co), and zinc (Zn), and nonessential, such as cadmium (Cd) and lead (Pb) [37]. An example of this contamination is the following: A known food company called for approximately 1,500,000 (one and a half million) kilograms of peanut butter after a suspicion of contamination with an iron shed from a defective machine [38]. Another example is the confirmation of the contamination of roasted peanut spinach with lead (Pb) in samples collected from main bus stations in Pan Khartoum (the triangular capital of Sudan). The source of contamination is the engine exhaust of the busses at these stations. That is, most of these automobiles used leaded fuel. This appeared in a Ph. D. thesis at Alahfad University for Women, Omdurman, Sudan (Eldirdiri, a radio interview, Omdurman Radio, Sudan Broadcasting Corporation, 2016). Heavy metals have deleterious effects (in overdoses) on humans and their environment. That is, they ignite cancer and negatively affect DNA, proteins, and lipids by giving rise to free radicals [39]. Metallic pollutants can be managed by a variety of methods, including waste biomass (such as peanut hulls and chitosan cross-linked beads) adsorption methods. Peanut hulls can be used as adsorbing materials for the removal of heavy metals from extracts. Peanut hulls exhibited 88.6 ± 1.9% cadmium removal without a reduction in phenols. However, the weak removal of arsenic by this method necessitates its use as an effective removal method for heavy metals only. That is, the percentage removal of arsenic was 21.7 ± 9.5% [40]. However, in the food industry in Canada, a metallic detection system involving sensitive sensors is used. An alarm sounds when a contaminated item passes through the conveying belt in front of the sensor and is consequently removed from the packaging. However, multiscanning inspection for metals can include X-ray detection devices [38].

3.1.2 Other physical contaminants

These include any hard food, such as jewelry, pieces of glass, plasters and bandages, staples, wraps of plastic and packaging materials, mummies of insects, parts of rodents, and crop residue (debris). That is, all the unwanted objects [41]. The management of physical contaminants in food can include PPE (protective personal equipment), such as hair nets and beard nets; the use of colored bandages to be easily seen and located if dropped into food items; the removal of food plants from jewelry, glass and other similar potential pollutants; the keen cleaning of fruits and vegetables; and the sound management of pests [41].

3.2 Chemical contaminants

These include unwanted chemical constituents from different sources that pollute food. They generally include two major groups according to their origin.

3.2.1 Industrial contaminants

Nitrate, chlorinated environmental contaminants of PCBs (polychlorinated biphenyls), dioxins, and chlorinated pesticides. Other environmental contaminants, such as brominated flame retardants and perfluorinated compounds, and contaminants formed during food preparations, *viz*. acrylamide, furan, 3-MPCD, and polycyclic aromatic hydrocarbons (PCHs) [42]. A plethora of chemicals used in industry in general and in the agri-food industry pollute the environment and eventually affect food safety in one way or another [43]. Some chemical contaminants can arise from chemical reactions in postharvest and cooking conditions. These include free radicals from rancidity in peanut. However, these chemical contaminants include synthetics such as cleaning products (e.g., detergents and sanitizers), pesticides, toxic chemicals in metallic and plastic containers, preservatives, etc., and disposal products from industrial plants such as chlorine, oil leaks and wastes, and radioactive residues.

3.2.1.1 Disposal and waste products

The byproducts of the industrial sector need proper disposal. However, there is usually no proper handling of these materials, which are mostly harmful to the environment. These include liquid chlorine water, ammonia, and other chemicals that endanger human life and the life of his domestics and pollute the environment and consequently any produce from it, directly or indirectly.

3.2.1.2 Environmental pollution

This concerns gas emissions and other radiants and pollutants as well. These include the industrial sector, automobiles, and other machines that emit radiation and pollutants. Advanced countries have a large share of environmental pollution, whereas the reverse is true for developing countries in terms of mismanagement of industrial disposal and pollutants. Both of these factors contribute to global warming panic. These contaminants can affect cultivated crops and peanuts. However, it may be worth mentioning that the International Atomic Energy Agency (IAEA) has performed interstate inspections of the irradiation. In Sudan, a colleague spoke about irradiation over the allowed limits in the Khartoum and Kordofan States. These include irradiation from a therapy unit and natural irradiation from indigenous sources (Hassan, joint occupational safety discussion).

3.2.2 Naturally occurring contaminants

These are the constituents of native origin. These compounds include the alkaloids that occur in tubers (e.g., potato) and fruits (e.g., tomato), *viz*., solanine, which can be observed as green islands. The toxicity of these chemicals depends on the dose taken; generally, the symptoms associated with them extend in severity from headache and digestive upset to convulsion and death [41]. Other native alkaloids of high toxicity are ricin and ricinine in castor bean oil [44]. In peanuts, such native contaminants, including IssgE proteins, which are known allergens, cause symptoms ranging from GIT upset to anaphylactic shock [15]. These harmful proteins include Arachis hypogea 2 (Ara h 2 constitutes approximately 60% of allergens), Ara h 6, Ara h 3, and Ara h 8 [25, 26]. Other allergens include 2S, 7S, and 11S [26].

3.2.3 Residues

Residues are the remains, remainders, or remnants of the chemical used in a treated material or untargeted material (passively). These include inputs in animal production, such as vitamins and antibiotics, as well as volume materials, such as the prion protein that causes bovine spongiform encephalopathy (BSE), and the justification of the transformation of this protein into a pathogenic form that damages the CNS is not yet well understood [45]. However, the interception of beef and chick meat from countries that consume animal protein has long occurred in some countries, such as Saudi Arabia (Addas and Alagab, separate personal discussions). That is, they believe that prion protein residues are the cause of this madness [45]. However, there is an interference between physical and chemical contamination because the residues of metals can also be considered to be similar to other chemical agricultural inputs.

Pesticide residues are among the most important residues in the food production, agri-food, and food industries. Due to the importance and the expected impacts of residues on human health and living possessions, international organizations of concern have set voluminous packages and regulations to manage such conflicting interests in the use of pesticides and chemical agricultural inputs in general. These organizations include the WHO, FAO, UNEP, IFAD, ILO, UNIDO, UNDP, etc. (Palestina, personal discussion). The WHO has annexes of the parameters needed to pass a pesticide for use at the international level [46]. However, every country has its own regulations for the use of pesticides, away from international organizations, but runs the same route of concern about health and safety. In Sudan, the National Council for Drugs and Toxins (NCDT) is responsible for the licensing of pesticides and drugs. However, any pesticide must be tested by the Agricultural Research Corporation (ARC) for two consecutive seasons with thorough residue analysis, regardless of international regulations. The results of the testing and screening will be presented at an annual meeting of the pests and diseases committee at the ARC HQ. A thorough discussion will determine whether a chemical can be passed for use at the commercial level [47]. With respect to peanuts, the pesticides used include those used against terrestrial pests and those that attack foliage. A characteristic and unique phenomenon of peanuts is their flowering and fruiting pattern. That's, the flowers send pegs to the ground and then set fruits underground. Therefore, residue from pesticides applied to the soil is more likely.

The residues were evaluated by sophisticated laboratory techniques, including thin layer chromatography (TLC), gas liquid chromatography (GLC), high-performance liquid chromatography (HPLC), gas chromatography–mass spectrometry (GC–MS), atomic absorption spectrometry (AAS), spectrophotometry, and other sophisticated rapid techniques, such as the use of check papers (paper strip-based sensors) [48]. The FAO/WHO Joint Meeting on Pesticide Residues (JMPR) determined the allowable residue limit for each pesticide for every crop. The allowed daily intakes (ADIs) and the acute reference doses (ARfDs) were also set [49]. Residue analyses of pesticides in peanut butter by the USDA/PDP (United States Department of Agriculture/ Pesticide Data Program) reported a number of insecticides in peanut butter. These include piperonyl butoxide at 26.9%, DDE at p,ṕ (3.7%), pentachloroaniline (PCA, 1%), quintozene (PCNB, 0.5%), fluazinam (0.3%), pentachlorobenzene (PCN, 0.1%), and malathion (0.1%) [50]. The safety margin is an important index in crop production and food quality. That is, the period postspraying and before harvest. This will allow the pesticide to be at the recommended allowed level that is not harmful to the consumer and is acceptable in local and international markets [51].

The preventive measures against chemical contaminants include the following:

1. Clean containers and the right label for the chemical containers were used.

2. The chemicals were used cautiously and carefully.

3. The cleaning procedure must be appropriate, and the cleaning materials must be washed carefully.

4. Cross-contamination was avoided by following the appropriate protective measures.

5. Pesticides must be used under experienced supervision in pre- and postharvest practices.

6. Use of sophisticated techniques in monitoring pollutants in food. These include nanomaterial-based electrochemical detection of chemical contaminants [52].

7. The residues in the import and export crops and in the local market were monitored by periodical checks.

8. Since the residue has a large reliance on preharvest practices, a good crop husbandry approach (a good agricultural practice, GAP) is mandatory and requires considerable critical knowledge. This necessitates the supervision of companies and/or official bodies to address these issues, including pesticide application [53].

3.2.4 Mycotoxins

The etymology of the prefix myco refers to the Greek word *mykēt, which means mushroom or fungus. Accordingly, the complex word mycotoxins refers to fungal poisons* [54]. Aflatoxins are fungal metabolites and byproducts that, when ingested, inhaled, or absorbed through the skin, cause lowered performance, ailment, or ultimately death in humans and domestic plants, including birds [55]. Aflatoxins were first discovered in Great Britain in the 1960s after an outbreak of a term "X disease" in turkey folk food, which was fed a contaminated imported peanut from Brazil. The contamination was determined to be due to a toxicant named aflatoxin, which is a fungus producer known as *Aspergillus flavus*. *A. flavus* is a fungus of great global concern because it is the causal organism of acute aflatoxicosis that caused an outbreak in the turkey folk in GB and mass death [56, 57]. However, the more important concern of this fungus is its ability to cause hepatic cancer "hepatoma." Accordingly, keen vigilance is given to imported and locally produced food and feed regarding this toxin [58]. The panorama of this *subtitle* may include the following: the types of mycotoxins and their sources; the set safety limits allowed for these toxins and the figures of different organizations, countries, and unions; the different methods of detection and appraisal of contamination by these toxins; the available protective measures and their applicability; and the treatment methodologies available to date.

3.2.4.1 Types and producers of mycotoxins

A number of toxins from fungal sources were identified decades ago. These mycotoxins include deoxyvalenol (DON), fumonisins, fusarium toxins, and other mycotoxins [acetoxyscirpenediol, acetyldeoxynivalenol, acetylneosolaniol, acetyl T – 2, aflatoxins, aflatrem, altenuic acid, alternariol, austdiol, austamide, austocystin, avenacein +1, beauvericin +2, bentenolide, brevianamide, butenolide, calonectrin, chaetoglobosin, citrinin, citreoviridin, cochliodinol, crotocin, cytochalasin E, cyclopiazonic acid, nevalenol (NIV), ochratoxins, and zearalenone] [59, 60].

3.2.4.1.1 Fusarial toxins

These secondary metabolites are produced by *Fusarium* spp.; they occur naturally in different cereals, and their presence is unavoidable at different concentrations depending on the surrounding factors. These include: 1. Trichothecenes (DON, T–2/HT–2 toxin, and nivalenol); 2. Fumonisins (FB1, FB2, FB3, and FB4); 3. Zearalenone (ZEA, ZON, and F–2 toxin), and 4. Moniliformin [61].

3.2.4.1.1.1 Trichothecenes

These species are not reported in hot and dry climates despite the presence of their known producers (*Fusasrium* spp.) [11].

Deoxynivalenol (DON): DON is produced by some Fusarium spp. in grains in the field or postharvest [62]. However, many mycotoxins have been reported from peanut and maize in East Africa. These mostly include aflatoxins, fumonisins, zearalenone, and deoxynivalenol [63]. The chemical formula of DON is $C_{15}H_{20}O_6$, whereas its IUPAC name is 3α,7α,15-trihydroxy-12-13-epoxytrichothec-9-en-8one [64]. It contaminates food and feed, and the risk to humans is through contaminated food or from animals fed contaminated feed. The health complications of DON include symptoms such as headache, severe nausea, abdominal upset, tiredness, and high body temperature. In addition, there are negative complications such as antagonism and reproductive interference [62]. DON is famous for the name vomitoxin (a potent vomiting-inducing toxin). It is also considered an immunosuppressant toxin; it has a negative effect on immune system activities and leucocytes and can cause death [65]. There has been a reported success in reducing DON contamination in animal feed (contaminated corn). That is, Don was adsorbed by an alginate/carboxymethyl cellulose sodium composite loaded with calcium (SA/CMC-Ca) made by emulsification in a microsphere adsorbent [66]. Three fungi were found to be effective at conjugating DON. These were *Alternaria alternata*, Rhizopus microsporus var. rhizodiformis, and Aspergillus oryzae. They are capable of transforming DON into conjugated hydrolyzable DON with a percentage range of 13–23% in PDA media and 11–36% in corn-based media. However, *Fusarium oryzae (F. oryzae)* was found to achieve 92% degradation of DON in corn-based media over 3 weeks [67].

T – 2: T – 2 toxin (fusariotoxin T2, insariotoxin, and mycotoxin T2) is a trichothecene fungal byproduct toxin. Its molecular formula is $C_{24}H_{34}O_9$. The T2 IUPAC name is (2α,3 α,4β,8α)–4,15–bis(acetyloxy)–3–hydroxy–12,13–epoxytrichothec–9–en–8–yl 3–methylbutanoate [68, 69].

T–2 is poisonous to humans and his domestics. It causes alimental aleukia symptoms such as nausea, vomiting, diarrhea, leukopenia, hemorrhaging, skin inflammation, etc., and cutaneous toxicity is not observed, despite some dermal effects [69]. Its LD_{50} is as high as 1 mg/kg bw. The EFSA (European Food Safety Association) set the average exposure amount of T–2 to be 12–43 ng/kg bw/day. This value is less than the TDI of 100 ng/kg bw for both HT–2 toxin [70]. The treatment of T–2 toxicity is mainly symptomatic, and no cure or medication is prescribed. However, it is advisable for charcoal to bind with this toxin upon ingestion, *i.e.*, it has excellent binding ability with T–2. However, prophylactics have also been reported to be useful in mitigating toxicity [71].

HT-2: HT-2 IUPAC name: [(1S,2R,4S,7R,9R,10R,11R,12S)–2–(acetyloxymethyl)–10,11–dihydroxy–1,5–dimethylspiro [8–oxatricyclo [7.2.1.0^{2,7}]dodec–5–ene–12,2′–oxirane]–4–yl]3–methylbutaoate. Its molecular formula is $C_{22}H_{32}O_8$. It is a product of Fusarium fungus and is also a byproduct of the metabolism of T–2 toxin. It is usually a grain contaminant, and accordingly, it is a risk to humans and their animals [72]. It has an advantage over T–2 in that it passes more easily through the blood brain barrier, causing neurotoxic apoptosis [73]. It has also been reported to affect anorexia [74] and weight loss [75]. No observed adverse effect levels (NOAELs) or lowest observed adverse effect levels (LOAELs) were derived for different animal species. In ruminants, an LOAEL was established for the sum of T2 and HT2 of 0.3 mg/kg body weight (bw) per day, based on studies with calves and lambs [76].

Nivalenol: Nivalenol (NIV) is a fusarial toxin that belongs to the trichothecene group. It is a major contaminant of cereal and cereal products in temperate, moist, and cool climates [77]. The chemical formula of this toxin is $C_{15}H_{20}O_{7,}$ and its chemical name is (3α,4β,7α)–12,13–poxy–3,4,15–tetrahydroxy–trichothec–en–8. NIV has been reported to alter many biological routes. The most famous pathway is the NF–kB pathway, which is a transcription factor and a constituent of rather all human cells. It alters cytokine expression. That's, it's a genotoxic agent. It also promotes the production of IL–8, an inflammatory mediator. It also affects MCP–1/CCL2, which govern mononuclear leukocytes [78, 79]. Chemokine secretion is inhibited by NIV, which negatively affects the immune system; all these studies were in small test animals [80, 81]. NIV has not been reported to have adverse effects on humans or domestics other than immunosuppression [82]. NIV is metabolized in the liver but also partly by GIT microbes. However, the main degradation component is the epoxy group, which is the most toxic, and the main deactivation product is de-epoxynivalenol [83]. The metabolites of NIV include acetyldeoxynivelenol, DON, and iso-deepoxy-DONglucuronides [84].

Diacetoxyscirpenol: Its other names are DIA and anguidine. The IUPAC name for DIA is 3α-hydroxy-12α,13-epoxy-trichothec-9-ene-4β,15-diyl diacetate. The chemical formula of DIA is $C_{19}H_{26}O_7$ [85].

Trichothecenes are classified into two categories according to their toxicity. This group has one of the greatest adverse effects on humans and their animals and includes T–2, HT–2, and diacetoxyscirpenol. The second group of less toxic compounds included DON, NIV, and 3- and 15-acetyldeoxynivalenol. However, it is worth mentioning that DON is of concern in Europe because it is the most prevalent trichothecene [86]. Like other trichothecenes, DIA does not require activation to react with host cell constituents. It also induces cytotoxicity, apoptosis, inhibition of nucleic acid synthesis, and mitosis [87]. No antidote for trichothecenes is known; therefore, treating affected patients symptomatically and administering charcoal powder orally when the toxin is ingested is vital [88].

3.2.4.1.1.2 Fumonisins

They are produced by Fusarium spp. and their Liseola section (including *F. verticillioides, F. proliferatum, F. subglutinans, and F. temperatum*) [89, 90]. There are four main types of FBs: FB_1, FB_2, $FB_{3,}$ and FB_4. However, a number of variable fumonisins have been reported in addition to other secondary metabolites, some of which do not occur naturally [91]. In addition, a peculiar fumonisin is produced in grapes infected with *Aspergillus welwitschiae* [92]. *Fusarium* spp. infect peanuts and contaminate them with FBs. That is, the highest FB contamination, which was 18,184 μg/kg, was reported in maize in Tanzania [63]. Nevertheless, the East African Bureau of Standards has set limits of 5 ppb for AFB1, 10 ppb for total AFs, and 2000 ppb for FBs in maize and peanuts [63]. The IUPAC name of fumonisin B2 is 2–[2–[19–amino–6– (3,4–dicarboxybutaneoyl)–16,18–dihydroxy–5,9–dimethylicosan–7Cyl]–oxy– 2oxoethyl] butanedioc acid. The chemical formula of fumonisin B_2 is $C_{34}H_{59}NO_{14}$. It is structurally analogous to fumonisin $B_{1,}$ which is less toxic than fumonisin B1, and both are cytotoxic. Fumonisin B_2 impedes sphingosine acyltransferase. It is a member of the monoterpene family that contains two isoprenes [93]. The PMTDI (permitted margin … daily intake) of FB1, FB2, and FB3, separately or together, is 2 μg/kg bw (2 PPb/kg bw), as set by the FAO/WHO/JECFA [93]. FB2 is hepatotoxic and nephrotoxic. It increases apoptosis and consequently cell regeneration. Other complications include bone marrow suppression, sepsis, hemosiderosis, leukopenia, and repeated hemorrhages. Other negative impacts include hypertension, angina, tachycardia, cardiovascular system dysfunction, and disruption of sphingolipid metabolism [93]. The PMTDI (permitted margin … daily intake) of FB1, FB2, and FB3, separately or together, is 2 μg/kg bw, as set by the FAO/WHO/JECFA [93]. Moreover, the East African Bureau of Standards (EABS) set regulatory limits for total fumonisin(s) in peanut and maize at 2000 ppb [63]. The gap between the limits set by international organizations and those set by regional organizations is very large (2 and 2000 ppb, respectively). This needs a quick revision, discussion, and action from the African and the international experts. That's, African health and safety truly matter.

3.2.4.1.1.3 Zearalenones

Zearalenone is a fusarial toxin also known as Zea, Zon, and F-2 [94]. It is also produced by *Gibberella* and mostly *G. zeae* [95]. It is mostly produced in the field and contaminates products [61]. However, many mycotoxins have been reported from peanut and maize in East Africa. These mostly include zearalenone, aflatoxins, fumonisins, and deoxynivalenol [63]. The IUPAC name of Zea is (3S, 11E)–14, 16–dihydroxy–3– methyl –3, 4, 5, 6, 9, 10–hexahydro–1 *H*–2–benzoxacyclotetradecine–1, 7(8*H*)–dione. However, its chemical formula is $C_{18}H_{22}O_5$ [96]. Zea is an analog of estrogen, and its metabolite α-zearalenol has a strong affinity for binding to estrogen receptors (xenoestrogens) [97, 98]. By doing so, it interferes with the reproductive activities of man and his domestics. The abovementioned effects include many sexual disorders, such as deformities in genital organs [99, 100], early puberty in females [101], a reduction in sperm and ova, and a decrease in the viability of the bearings [102]. The topical exposure of humans to zea has not been associated with any expected hormonal complications [69]. The tolerable daily intake of zea is reported to be 0.25 g/kg bw [103]. However, no acute toxicity of zea has been reported. Treatment of zea by nontoxic microbes results in its detoxification, in addition to the success of detoxifying zea by adsorption and biotransformation [104].

3.2.4.1.1.4 Moniliformin

It is a product of a number of *Fusarium* spp. (*avenaceum*, *subglutinans*, *proliferatum*, *fujikuroi*, etc.). Its IUPAC name is sodium 3,4–dioxo–1–cyclobutene–1–olate. The chemical formula of this mycotoxin is NaC_4HO_3. However, it is hazardous to the cardiovascular system because it is cardiotoxic and interferes with respiration by obstructing the functions of the pyruvate dehydrogenase complex. It also causes hypertrophy of the ventricles. These complications are induced by the sodium salt of deoxysquaric acid (semisquaric acid) [105]. The major symptoms of acute Mon toxicity include muscular fatigue, difficulty breathing, myocardial degeneration, sickness, and changes in organs (e.g., kidney, pancreas, and lungs). In severe toxicity, coma and mortality are expected [106].

3.2.4.2 Aflatrem

Aflatrem is strongly tremorgenic and is a product of terrestrial *Aspergillus flavus*. It is a bundle of different byproducts known as indole–diterpenes [107]. Its chemical formula is $C_{32}H_{39}NO_4$, and its IUPAC name is (1S,4R,5S,16S,19S,23R)-19-hydroxy-4,5,24-tetramethyl-12-(2-methylbut-3-en-2-yl)-25,26-dioxa-7-azaheptacyclo[21.2.1].$0^{1,20}.0^{4,19}.0^{5,16}.0^{6,14}.0^{8,13}$]hexacosa-6(14),8,10,12,20-pentaen-22-one. At a dose of 3 mg/kg, aflatrem reduced the transmitter GABA (gamma amino butyric acid) and glutamate capacity in the rats beginning on day 1. This is attributed to the effect of these toxins on nerve terminals [108].

3.2.4.3 AFXs

Aflatoxins are mainly produced by two fungi, *Aspergillus flavus* and Aspergillus *parasiticus*. The first fungus produces B aflatoxins (AFB1 and AFB2), whereas the latter produces both AFB and G types (AFG1 and AF2). Only half of the strains of *A. flavus* are capable of producing aflatoxins (toxigenic fungi), whereas 99% of the strains of *A. prasiticus* can produce aflatoxins [11]. The shedding of ultraviolet light into AFBs, AFGs, and AFM_1 yields the following: 1. The blue color indicates AFB_s and AFB_2; 2. Green indicates AFG_1 and AFG_2, and 3. Blue–violet color for AFM_1 [109, 110].

3.2.4.3.1 AflatoxinB

The AFB_1 IUPAC name is (6aR,9aS)–4–methoxy–2,3,6a,9a–teterahydrocyclopenta [3′,2′.4,5] furo [2,3-h] [1] benzopyran–1,11– dione. Its chemical formula is $C_{17}H_{12}O_6$ [111, 112]. It is mainly produced by *A. flavus* and *A. parasiticus*. It is a super potent hepatocarcinogen [113]. AFB1 is a known contaminant of peanuts and many foods, including cottonseed and grain, in addition to feed [114]. Ingestion of AFB1 causes many health complications, including immunosuppression, teratogenicity, mutagenesis, and hepatoma, and is a chronic ailment. However, aflatoxicosis is an acute sickness caused by AFs [115, 116]. It can also cause infection in humans through the skin or inhalation. Infection can cause many complications due to the growth of the fungus *A. flavus*, which has long hyphae and colonizes the lungs, respiratory tract, or even cavities around the brain. This may also cause death and other fatal complications that require surgical intervention and long-term treatment (Ahmed, the National Medical Laboratory, Khartoum, joint work and consultancy, 2001). However, a master's student at the University of Khartoum died from infection due to the fungus he was working on in his laboratory in the 1980s (Bhagdadi, personal discussion). The tumor dose that causes half of the test population without tumors throughout the test period (TD_{50}) for AFB_1 is 3.2 μg/kg/day in rats [117]. The oral LD_{50} for AFB1, which causes acute toxicity, ranges between 0.3 and 17.9 mg/kg bw for most animal species [118]. The maximum permitted level (mpls) of total AFs set by the US FDA is 20 μg/kg (ppb) in all food items [119], despite milk having a mpl of 0.5 ppb [120]. However, 100–300 ppb TAF is permitted in feed in the USA [120]. However, for the EU, mpls are 2–12 ppb for most foods and only 0.1 ppb for AFB1 in infant foods [121]. The corresponding values for the JECFA/FAO/WHO are 15 ppb for the total AFs in raw peanuts and only 10 ppb in processed peanuts [122]. However, the mpl of AFB1 alone is 5 ppb in dairy cattle feed [123].

3.2.4.3.2 AFX B2

The chemical formula of AFB_2 is $C_{17}H_{14}O_6$, and its chemical name is Cyclopenta [c]furo [3′,2′,4,5] furo [2,3-h] [1] benzopyran-1,11-dione, 2,3,6a,8,9,9a-hexahydro4-methoxy-, (6aR-cis) [124]. It is less toxic than AFB_1. It is mainly produced by *A. flavus* and *A. parasiticus*.

3.2.4.3.3 Aflatoxin G1

Aflatoxin Gs are coumarins. That's, they are benzopyrones and hepatotoxic. They are mainly produced by *A. parasiticus*. The IUPAC name of AFG_1 is 11–methoxy–6,8,16,20–tetraoxapentacyclo[10.8.0.$0^{2,9}$.$0^{3,7}$.$0^{13,18}$]icosa–1,4,9,11,13(18)–pentaaene–17,19–dione, and its chemical formula is $C_{17}H_{12}O_7$. The acute toxicity of this toxin is characterized by the following symptoms: skin and eye irritation, vomiting, abdominal colic, hemorrhage, and pulmonary edema [125]. The treatment is mainly symptomatic, and no antidote is available.

3.2.4.3.4 Aflatoxin G2

The AFG2 IUPAC name is (3S,7R)–11–methoxy–6,8,16,20–tetraoxapentacyclo[10.8.0.$0^{2,9}$.$0^{3,7}$.$0^{13,18}$]icosa–1,4,9,11,13(18)–tetaene–17,19–dione, and its chemical formula is $C_{17}H_{14}O_7$ [126]. It is mainly produced by *A. parasiticus* [125]. B and G are the least toxic aflatoxins.

3.2.4.3.5 Other aflatoxins

Aflatoxins other than those in the B and G groups include AFM_1, which is a metabolite of AFB_1 in humans and animals. It is usually found in milk and possibly in meat. AFM_2 is a common contaminant of milk and animal food products and a product of AFB_2 [127]. AFQ_1 is an *in vitro* product of AFB_1 metabolism in the liver of higher animals, and aflatoxicol is a product of the breakage of the lactone ring [128]. AFM, AFQ, and AFL can be used to detect epoxides. However, they are far less toxic than their original sources [129].

3.2.4.3.6 Protective measures against aflatoxins

3.2.4.3.6.1 Aflatoxin analysis

The general appearance of the seed: A healthy seed lot has the typical appearance of a peanut seed. That's, a sound seed with no spots, intact, no pits, clear of breaks, and any abnormality, generally speaking.

Checking for toxins: This can be performed through a variety of methods that can meet demand and availability requirements. These tests include the aflacheck® test, which is a rapid and easy-to-apply method; the other immunoaffinity test is the enzyme–linked immunosorbent assay (ELISA) [11].

Other tests require high-quality and precise equipment and instrumentation. These include TLC (thin layer chromatography), high-performance liquid chromatography (HPLC), gas chromatography–mass spectrometry (GC–MS) and high-performance thin layer chromatography (HPTLC) [11].

3.2.4.3.6.2 Preharvest aflatoxin preventive measures

These include the following.

1. Avoidance of drought stress 2. GAPs (good agricultural practices), which include good weeding, insect control, and recommended spacing; 3. Avoidance of breakage in the seed lot and use of grading to eliminate unsound seeds. 4. Considering that *A. flavus* is a commensal fungus in the field, adopting the GAP approach will at least minimize its occurrence. 5. Use of resistant varieties by AF producers.

Preventive postharvest measures for aflatoxin treatment.

1. The harvest was kept *dry* and *cool*. 2. Good harvesting methods can end with sound seed lots. 3. Good transportation (no contamination, no seed damage, etc.). 4. Competitive exclusion biocontrol is also helpful. 5. The harvest was inspected to eliminate unsound seeds due to damage, coloring, etc..... 6. Good storage is needed.

3.2.4.3.7 Aflatoxin treatment

The occurrence of aflatoxins is inevitable [61]. Accordingly, methods for treatment are highly needed to detoxify these toxins and contaminants in food commodities. A number of methods and trials have been reported to address this concern. These include the following:

1. Good manufacturing practices, as mentioned earlier, can remove aflatoxins by proper refining of oil.

2. The bacterial strains *Lactobacillus* sp. and yeast can detoxify AFB_1 by 60 and 65%, respectively [130].

3. Lactic acid bacteria (LAB) strains were used to detoxify AFB_1 and ochratoxin A (OTA). *Lactococcus lactis* ssp. *lactis* 1, *Lactococcus lactis* ssp. *lactis* 2, and *Lactobacillus paracasei* ssp. *paracasei*, were specifically identified by molecular biology as *Enterococcus faecium* and *Enterococcus durans*. The removal ability of both AFB1 and OTA was 50%, regardless of the viability of the bacterial cells [131].

4. Extracts of 13 herbs were tested for aflatoxins. The most potent of these extracts against the mentioned toxins were *Hybanthus enneaspermus*, *Eclipta prostrata,* and *Centella asiatica*. Therefore, 70% of AFB1 detoxification was confirmed by GC–MS [131].

5. The juice of lime (*Citrus aurantifolia* L.) was used to detoxify AFB_1 in peanut paste (Dakwa). The results revealed a reduction in AFB_1 of 11 and 31% after treatment with 0.5:1 and 1:1 lime juice (ml): Paste (g) for 1 day, respectively. In addition, the corresponding results after 3 days and 7 days of storage of the abovementioned proportions were 54 and 66% and 74 and 92%, respectively [132].

6. Bioagent detoxification of AFs is an environmentally friendly technique and innovation. These materials are specific, tolerate high temperatures, and do not harm the environment. The probiotics *Bacillus subtilis* and *B. velezensis* are highly effective at degrading AFs [133].

7. Ammoniation is considered the best aflatoxin detoxification technique for grain. This approach is easy, applicable, and economical at the commercial level [134].

8. High-temperature treatment is used by some researchers to degrade AFs. However, this is not a suitable technique because of the following

    a. AFs are resistant to high temperatures up to 300°C [55].

    b. High temperature may reduce aflatoxin contamination but will negatively affect food quality drastically.

3.3 Biological contaminants

There are two main categories of store product insects (SPIs) of grain: primary and secondary pests. The primary pests penetrate and directly damage the grain or seed, whereas the secondary ones are opportunistic and make use of the damage caused by the primary ones or any other ones to further damage and feed on them. The damage caused by secondary pests is sometimes far greater than that caused by primary pests. The SPIs that may contaminate peanuts include the following: lesser grain borer (Rhyzopertha dominica L.), grain weevil [*Sitophilus* spp. (*oryae*, *Zeamais*, and *Granarius*)], red flour beetle (*Tribolium castaneum* Herbest), loose flour beetle (*Tribolium confusum* Jacquelin du Val), Weevils [*Sitophilus* spp. (*zeamais*, *Garanarius*, and *oryzae*)], sawed–toothed grain beetle [*Orazaephilus surinamensis* (L.)], booklice, psocids, (Liposcelis bostrychophila Badonnel.), almond moth [*Ephestia keuhneilla = Cadra cautella* (Walker)], Angoumois grain moth [*Sitotrga cerealella* (Olivier)], dermestids [Khapra beetle (Trogoderma granarium Everst) *and* warehouse beetle (*Trogderma variabile* Ballion)], flat grain beetle [Cryptolestes ferrugineus (Schönherr)], bruchids [bean weevil (*Acanthoscelides obtectus* Latreille)], larger grain borer [Prostephanus truncatus (Horn)], cowpea bruchid [*Callosobruchus* maculatus (Fabricius)] and some moths such as the almond moth [*Ephestia cautella* (Walker)] [11]. The management of these pests begins in the field, followed by storage. These include cultural, biological, chemical, legislative control, and the production of resistant cultivars and IPM [11].

4. Organic production approach

The production of organic matter, which is a naturally produced food, has received vigilance and a focus all over the world. That is, organic (sometimes known as bio) food commodities are more expensive, often folded, than ordinarily produced ones. This reflects the importance of the economies of such production and its health impacts. From the point of view of contaminants, this approach plays a large role and has a large role in solving this problem. The slogan of the environmentalist "Back to Nature" is valid here.

5. Conclusion

The peanut plant (*A. hypogea*) is an important food crop that is rich in protein, oil, and other essential minerals and nutritional elements, such as dietary fibers. It is an important global item in food security plans. That is, it has, rather, an unavoidable appearance at the dining table in a mosaic of recipes such as appetizers, dressings, sauces, salads, stews, and spinach for the rich and the poor.

The contaminants of peanuts and their products play a determining role in their marketing and food safety concerns. These contaminants can be natural (peanut constituents), physical, chemical, biological, industrial, or any other foreign material. The most important of these with respect to national and international trade are mycotoxins and their residues. The vigilance is focused mostly on aflatoxins for mycotoxins and pesticides for mycotoxins. Aflatoxins are fungal poisons that were first reported in 1960 in a mass death of turkey in England when the diagnosis concluded to be a disease called turkey-X disease, which was later defined as a toxin secreted by a fungus identified as *Aspergillus flavus,* and the disease is termed after the causal organism as well (aspergillosis), which was reported to kill a postgraduate student at the University of Khartoum in the 1970s who worked on it. Other mycotoxins of importance are ochratoxins and an endless list of fungal toxins and their metabolites. The residues can be physical, such as metals (lead, Pb), from automobile exhaust, iron (Fe) pieces and powder from defective machines, chlorine from unbalanced treated water, etc. However, pesticide residue is a mandatory issue in the checklist of safe food sold in markets. That is, many concerns have been reported and nullified many contracts and reversed shipments to their homelands. Accordingly, international food safety organizations have reacted promptly to these situations and set safe margins for mycotoxins and residues in different food items. That is, EFSA and CONTAM (European Food Safety Association, Contaminants on Food Chain Panel) specified 4–15 and 2–8 ppb (μg/kg) for total aflatoxins (AFTs) and aflatoxin B1 (AFB1), respectively, whereas the corresponding figures from the USFDA (United States Food and Drug Administration) and SSMO (Sudanese Standards and Metrology Organization) were 20 and 20 ppb, respectively; Codex.

10–15 and 10–15; FSSAI (Food Safety and Standards Authority of India) 15 and 10, and FSANZ (Food Standards Australia and New Zealand) 15 and 15 ppb, for AFT and AFB1 in peanuts and nuts, respectively. For pesticide residues, the maximum allowed levels were set by the joint committee of the FAO and WHO for each food item in annexes available for the experts and the public on their websites. For biological contamination, quarantine inspection is a standby service and duty at airports, seaports, and land terminals. Some outbreaks of diseases were made by improper checks, and a citing example of this matter was the USA outbreak of typhoid due to shipments of mango treated with hot water contaminated with *Salmonella typhi* in the last century.

The management of food contamination requires multidisciplinary plans that include preventive and curative actions. For physical contamination, there are many preventive rules, such as good practices and maintenance of tools and machines. The integrative curative measures include checking the products for contamination, sensitive sensors, toolkits, and keen macroscopic and microscopic vigilance of the samples by the quality management authority. Prevention of aflatoxins necessitates preharvest measures that include good agricultural practices (GAPs) for preharvest time and keen quality postharvest handling. In addition to some methods of treatment tested and passed worldwide, such as good manufacturing practices (GMPs, e.g., proper refineries of oil), *Lactobacillus* sp. bacteria (detoxifying AFB1 and OTA), reported a 60–65% reduction in lactic acid bacteria [*Lactococcus lactis* ssp. *lactis (1 and 2), Lactobacillus paracasei* ssp. *paracasei*, which were precisely identified as *Enterococcus faecium* and *Enterococcus durans], reported a 50% reduction; some herbal extracts achieved a 70% reduction (e.g., Hybanthus enneaspermus); lime juice was tested* *against AFB1 and reflected up to a 92% reduction; and ammoniation in grains; however, fermentation was found to be effective in reducing AFT by up to 84%; that is, the use of Lactobacillus rhamnosus* yoba 2012 and *Streptococcus thermophilus* C106 did so in fermented maize in Uganda [135]. However, in Finland, some researchers have reported the ineffectiveness of the fermentation in reducing AFM in yogurt (Korhonen, H. J., personal discussion at University of Nairobi, October 2012). The allergens of the peanut must receive more extensive research attention for the benefit of consumers, especially in developing countries where protein hunger is dominant, and for kids because of this important component in snacks and spinach shelves. However, the adoption of modern techniques for the detection of contaminants, together with efficient rapid detection techniques (RDTs), which are time-saving and highly practical whenever needed, is mandatory. An example of a modern technique is the use of nanotechnology for the detection of chemical contaminants [52], and for RDTs, an Aflacheck® (of Waters Incorporation, USA) is used for the rapid detection of aflatoxins in minutes. It may be worth discussing the intracalibration and intercalibration of the contaminants in the analytical devices. That is, the devices of the same brand and those bearing different brands were calibrated. The results of the analysis of a sample may differ significantly when different brand devices perform the same task. The UN organizations perform international calibrations of the devices of the known attested national and international test organizations and institutes. To my good knowledge, this check is periodical but lacks extensive inclusion of more institutes and shortening of the check period. I guess it may be better to do it every few years and in a rotating plan and to be considered as a mandate to keep the name of the firms as internationally authenticated. The research work, in essence, must include full information about the devices used in the analysis with their brands and the full details of any step that may significantly affect the results since the figures of the contaminants are so minute and in ppb. What is mentioned is necessary for safety and trade in general and for national safety and trade in particular because international trade and safety have precise and efficient check procedures, but doing so requires considerable time and tedious work.

Some controversies, paradoxes, or conflicts may arise from the research interest in the treatment of aflatoxins with thermal methods. However, more cooperation and illumination are needed considering food quality and the adverse effects of overheating on the constituents of commodities. An example of this is the boiling of milk, a common habitual trend in developing countries, which degrades many essential elements of this necessary food item. The heating of milk beyond 60°C results in the denaturation of vitamins, proteins, and other important components. This is why Lewis Pasteur invented pasteurization. Accordingly, the use of other detoxification techniques is the right choice. However, aflatoxins are reported to degrade in very acidic ($pH < 3$) and very basic ($pH > 10$) media and melt at 237°C and 299°C for AFG1 and AFM1, respectively. However, autoclaving is capable of removing aflatoxins, but normal cooking cannot [136].

Another important concern in the treatment of aflatoxins and other peanut and food contaminants is the products of these methods. That is, some metabolic processes may result in the production of more toxic metabolites than the toxin itself, as in the case of arsenite and monomethylarsonous acid [137].

Another important concern in the treatment of aflatoxins and other peanut and food contaminants is the products of these methods. Therefore, some metabolic processes may involve the metabolites of AFB1/AFG1 and AFB2/AFG2, which are AFM1 and AFM, respectively. These findings have been reported in nursing mothers and milking animals. They are more hazardous to infants, babies and younger kids than their precursors due to exposure. This was reported in sizeable amounts in the milk of nursing mothers in Sudan Gezira, Africa (Ahmed, I. A. M. Joint Supportive Consultancy, 1994). The fate of the byproducts of AFB1 removal from lime juice is not yet known.

More thorough research on these aspects is mandatory and needed. However, for pesticides, malathion intoxication and malathionic acid in the form of malathion upon its degradation in stores are also interesting.

Preventive measures for aflatoxin and mycotoxin occurrence and other food contaminants must be taken seriously because they necessitate the avoidance of any need for further treatment(s). The most important of these may be the maintenance of coolness and dryness, the avoidance of drought spells, and GAP, in the broadest sense.

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