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FOOD SAFETY OF PEANUTS MARKETED IN THE DEMOCRATIC REPUBLIC OF CONGO (DRC) : STATE OF RESEARCH ON MYCOTOXINS

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***Abstract*- Due to their nutritional quality and economic potential, peanut occupies a place of choice in the daily lives of congolese and requires special attention. This investigation reviews relevant research in the DRC and other countries on fungi and the mycotoxins they secrete in food, particularly in peanuts. Although incomplete, data show that Aspergillus is generally the fungal micro-organisms commonly contaminating peanuts marketed in the DRC and other countries. Aflatoxins are the mycotoxins most found in this food, especially since they are the most sought-after. However, the level of these toxins in peanuts is higher than the american aflatoxin standard (20 µgKg^{-1}) and the european standard (4µgKg^{-1}) and varies according to the different fractions : 10-54393 µgKg^{-1} of aflatoxin B1, 200-21092 µgKg^{-1} of aflatoxins B2, 217-31029 µgKg^{-1} of aflatoxins G1 and 230-20193 µgKg^{-1} for aflatoxins G2. Other toxigenic fungal species can also contaminate peanuts and excrete other mycotoxins such as ochratoxin A (OTA), beauvericin, cyclopiazonic acid, nivalenol, moniliformin, and others. The incidence characterizing the contamination of peanuts by mycotoxigenic species is governed by several environmental factors, the main ones being temperature and moisture. Tropical countries such as the DRC are preferred environments for food development and fungal contamination, especially peanut. Unfortunately, the DRC does not yet have a national policy for the monitoring of these contaminants and the health and economic impact is not yet known.**

***Keywords* : "Peanut", "mycotoxins", "aflatoxins", "fungi", "DRC".**

I. INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is the sixth most important oilseed crop in the world [1] [2]. It is cultivated in 96 countries around the world [1] and occupies a prominent place in the daily lives of congolese where it is a very important food and economic source for many households [3] [4]. Nutritionally, peanut contains sugars, fatty acids, vitamins, minerals, and proteins composed of essential amino acids (lysine, arginine, and methionine) [5] [6]. Peanuts are identified as very interesting as a food rich in nutrients in the Democratic Republic of the Congo (DRC), where 43% of the population (children, pregnant and lactating women) promote chronic malnutrition, characterized by deficiencies in vitamin A and iron [7] [8] [9] [10].

Economically, groundnuts are a source of income for the rural-peasant population, which accounts for more than 80% of agricultural production. It is a cash crop and also an industrial one (oil extraction, feed with cakes). It is the most financially accessible and most marketed foodstuff (47%) ahead of corn (44%) and rice (36%). Particularly, it is sold in retail in smaller units (glasses, goblets, bottle caps, piles) for a derisory price. Annual production is estimated at 1.1 million tons, among which 800,000 tons are available on the national market [11] [12].

Peanuts are eaten in several forms (raw, boiled, or roasted) as a snack or appetizer at partis, cocktail parties, around a drink, or at any other occasion. Peanut paste, called “moambe” is obtained from the grinding of roasted peanut seeds and is used to season several dishes and to prepare peanut butter which is much appreciated especially when it accompanies bread. Hence there are several moambe recipes on the congolese menu : rice, chicken, caterpillars, vegetables, salted or smoked fish, etc.

However, seeds (peanuts) are very sensitive to contamination by molds, some of which secrete mycotoxins, such as *Aspergillus flavus*. Moreover, the outbreak of current mycotoxicology started from the contamination of peanut cake by aflatoxins, the poisoning which caused the death of 100,000 turkeys in London in 1960. The disease that resulted was called the ‘Turkey X’ disease [13]. This contamination can occur at any time, before or after harvest, drying, storage, transportation, or even during processing into by-products, thus causing changes in organoleptic and chemical characteristics, causing enormous agricultural production losses [14]. Mycotoxins are potentially dangerous for human and animal health by causing a great many pathological effects, in particular cancers, poisoning or organ function disorders, vomiting, etc. [15] [16] [17] [18] [19].

According to the World Health Organisation (WHO), mycotoxins are responsible for approximately 600 million cases of morbidity including 420,000 deaths worldwide. Children are the most vulnerable with more than 120,000 deaths per year. This situation constitutes a major public health problem, especially in low-income countries [20], [21]. However, several cases of massive and even epidemic poisoning caused by the consumption of food contaminated with mycotoxins have been reported in humans and livestock around the world [13] [22]. To date, approximately 4.5 billion people in developing countries are exposed to foodstuffs whose contamination by mycotoxins is not controlled [23].

It's the case of the DRC whose geographical position (climatic variability, temperature, and high humidity) also offers a very favorable environment for the growth and contamination of food, in particular, peanuts by mycotoxigenic fungi [15] [24]. Unfortunately, the country does not have a national policy for the management of food contaminants (mycotoxins and others) in order to protect the population. Very few studies and information are available on the mycotoxins that contaminate food, such as peanuts that the congolese population consumes [25] [26]. In recent years, groundnut research has been more geared towards varietal improvement with the aim of developing varieties tolerant to rosette and leaf spot, in order to reduce the considerable yield reductions caused by these diseases [7] [11].

In order to contribute to the improvement of the sanitary quality of food in the DRC, this review of the literature strives to gather and present available information on the current state of research on mycotoxins found in the groundnut marketed in the DRC.

2. WORK METHODOLOGY

The documentary analysis was used as the methodological approach which was used to collect various data for 3 years, i.e. from 2019 to 2022. The various documents (articles, books, reviews, end-of-study dissertations, theses, reports, etc.) were compiled mainly from different websites (google search, google scholar, research gate, academia.edu). Those containing necessary information relating to mycotoxins were downloaded and analyzed. Other documents were obtained from local university and research institutions libraries (University of Kinshasa, National Pedagogical University, Catholic University of Congo, Regional Center for Nucelear Studies of Kinshasa and National Institute for Agronomic Studies and Research). To be retained, the document should have at least information on food mycotoxins and especially peanuts produced and/or used in the DRC or even in other countries. A total of 71 documents were selected and collected for analysis.

3. NUTRITIONAL PEANUT CONSTITUENTS

With the exception of oils, peanut contains many compounds that contribute to the maintenance and proper functioning of the body. It is composed of proteins, fibers, polyphenols, antioxidants, vitamins, and minerals which serve as enriching ingredients and are generally added to many processed foods. Other compounds like resveratrol, phenolic acids, flavonoids, and phytosterols are also present in peanuts. Peanut proteins are a good source of amino acids and co-enzyme Q10, with more large amounts of arginine, essential for animal organisms [5] [27].

Table 1 : Nutritional constituents per 100g of peanuts

Nutrients	**Nutritional value**	**Yields (%)**
Energy	567 Kcal	29
Carbohydrate	16.13 g	12
Proteins	25.85 g	46
Total lipids	49.24 g	165
Dietary fiber	8.5 g	22
Vitamins		
Folic acid	240 µg	60
Niacin	12.066 mg	75
Pantothenic Acid	1.765 mg	35
Pyridoxin	0.348 mg	27
Riboflavin	0.135 mg	10
Thiamin	0.64 mg	53
Vitamin E	8.33 mg	55.5
Electrolytes		
Sodium	18 mg	1
Potassium	105 mg	5
Minerals		
Calcium	92 mg	9
Copper	1.144 mg	127
Iron	4.58 mg	57
Magnesium	168 mg	42
Manganese	1.934 mg	84
Phosphorus	76 mg	54
Selenium	7.2 µg	13
Zinc	3.27 mg	30

Source : [5] [27] [28]

4. PEANUT GROWING IN DRC

Groundnut is an oilseed grown in semi-arid and subtropical regions of the planet between 40° altitude N and S on either side of the equator, and in more than 100 countries across all continents [29] [30].

Groundnut cultivation in the DRC is practiced throughout the national territory, but more particularly in the province of Kongo central, the former provinces of Bandundu, and the two Kasaï. Cultivation is done at the beginning of the rainy season (agricultural campaign A: September-December) and B (January-April) [8].


1 2

Fig.1 : Experimental groundnut field in bloom on the site of the General Commission for Atomic Energy (GCAE) / Kinshasa-DRC.
Fig. 2 : Experimental field of mature peanuts on the site of the GCAE / Kinshasa-DRC
Source : Our investigations

More than 85% of agricultural production is carried out by peasants. The harvest is done by uprooting the whole plants (leaves and pods) by hand and takes place immediately after maturity to avoid rotting and seed germination in case of soil humidity. Whole plants are left to dry in the field and then threshed to separate the pods from the fans. The dried groundnut is stored in pods in bags and/or shelled and winnowed for sale [28] [31].

To deal with diseases and challenges related to climate change impacting groundnut production, the National Seed Service (SENASEM) and research institutions have conducted research to develop and even import new varieties (improved varieties) that resist these threats and yield higher yields across the DRC. The main varieties are ICGV-SM 96722 ; ICGV-SM 281 ; ICGV-SM 01506 ; ICGV-SM 99588 ; ICGV-SM 86021 ; ICGVSM 95530 ; ICGV-SM 95523 ; ICGV-SM 98541, A1408, JL 24, G 17, [12] [32] [33].

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3 4

Fig.3 : Sale of groundnuts contained in the bags at the Matadi Kibala Market /Kinshasa.
Fig. 4 : Peanuts for sale contained in the basins at the Matadi Kibala market/Kinshasa-DRC.
Source : Our investigations

5. CONTAMINATION OF PEANUT BY MYCOTOXIC FUNGI, FAVORING FACTORS

Naturally, the contamination of food by molds constitutes a permanent and hardly unavoidable risk, especially in low-income tropical countries, where eco-climatic factors play a key role in the proliferation of mycotoxigenic molds in a very deleterious socio-economic context. Temperature and atmospheric humidity are the main environmental factors that govern the contamination and production of mycotoxins in food, especially peanuts. With an annual rainfall of 1200-2000mm, temperature and atmospheric

humidity above 25°C and 30% respectively, DRC is a breeding ground for the growth and development of mycotoxic fungi [24] [34]. Contamination begins in the field and continues through the harvesting, drying, handling, and storage process.
Apart from natural conditions, there are other factors that modify the contamination of groundnut with molds.

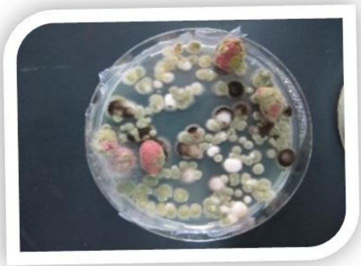

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Fig. 5 : Growth of molds contaminating peanuts on Sabouraud's medium after 6 days at the Microbiology laboratory of the GAEC/ Kinsha.
Fig. 6 : Growth of peanut-contaminating fungi on the water-soaked papers after 6 days at microbiology laboratory of the GAEC/Kinhasa
Source : Our surveys

5.1. The geocarpic nature of groundnut
This is the particular character of groundnut : the pods develop and mature in the ground. Yet, the soil is the natural reservoir or habitat of microfungi. This permanent soil-pod contact makes peanuts a very sensitive food to contamination by micro-organisms, especially fungi. This is why several species of soil fungi have been isolated from the pods and seeds of rotten and healthy groundnuts [16] [35]. The influence that the soil exerts on the mycotic flora can vary significantly according to the type of soil. For example, peanuts are grown on light, sandy soil promotes rapid mold growth, especially under drought conditions, while on heavy soil there is less contamination because of the soil's great ability to retain water, which makes it easier for the plant to prevent water stress [36] [37] [38].
5.2. Peanut hygroscopicity
Temperature, atmospheric humidity, and that of the peanut seed are the main environmental factors that govern contamination and the production of mycotoxins. Seeds constitute a hygroscopic material capable of exchanging water in the form of vapor with ambient air. Dry grain can become moist in contact with moist air [31]. Thus, these different humidity exchanges take place during the storage of the seeds and can rehydrate them from atmospheric water or by transfer of water vapor within the stock between hot spots and cold spots, which usually leads to mold growth. This is possible if the seed has a water content between 10% and 35% [14]. For *Aspergillus flavus* for example, a water activity (Aw) of 0.84-0.86 and a temperature between 25 and 40°C are sufficient for the development and production of aflatoxins in a peanut seed or any food [13]. Tropical countries generally give particularly hot and humid ambient conditions which stimulate the increase of the biological activity of the seed and the development of fungi.
5.3. The nutritional richness of the peanut
Generally, fungi like other microorganisms need a source of energy (carbohydrates, vegetable oils), a source of organic or inorganic nitrogen, and trace elements in the presence of available humidity for their growth. Hence, the substrate must offer a substitute for contamination to take place [39], and the groundnut offers an arsenal of ingredients necessary for mold multiplication.
Fungal contamination and the production of mycotoxins can occur in the field where insects attack the surface of the grain, facilitating the access of molds to the internal structures which contain the nutrients and increasing the risk of contamination of the edible part of the seed.
5.4. Carriage conditions
The evacuation of agricultural products from production areas to consumption centers in the DRC has always been hampered by many difficulties presented by the main means of transport, main road, river, and rail [40]. The national road network is insufficient to cover an area of 2. 345.000 km^2 and is in a very advanced state of disrepair. It has barely 1.3% of roads are paved with bitumen and 4.7% of dirt roads out of 154,400 km of road available in the country. The condition of agricultural feeder roads is generally precarious [41]. River transport is done by canoes or whaleboats in insufficient conditions and often presents great danger, even for users. The railroad which was created and more used during the colonial era is today less and less used because of the dilapidated state of the railroad and the lack of a locomotive [15]. Following all the above, the transport of agricultural products such as groundnuts is done under conditions where the risk of contamination by microorganisms such as molds and their mycotoxin is remarkably high.
5. 5. Drying conditions and duration
Heat-drying agricultural product is an old process ; the least expensive ; used to dehydrate the harvest with the aim of stabilizing and preserving the grains since ancient times. There is a reduction in humidity (amount of water) through evaporation and a reduction in favorable conditions for fungal growth and insect infestation. Ayodele and Edema [42] demonstrated in a study that drying is the critical control point to reduce mycotoxin contamination during the manufacture of yam chips. For the success of

peanut drying, the operation must be done as quickly as possible until the humidity is below 13% because within 3 days, quantity of mycotoxins such as aflatoxins can multiply by 10, as in maize [37].

5.6. Storage and preservation

Groundnuts are stored in airtight containers or in polyethylene bags placed in a warehouse where the grains are only dumped in traditional granaries. Storage by the pods is easy and exposes the groundnut less to various contamination factors (insects, humidity) and keeps it for a long time.

The DRC does not yet have adequate infrastructure for the conservation and storage of agricultural products. The country is struggling to emerge from a long period of conflict and political instability, the devastating impact of which is felt on the socio-economic level. The existence of several clandestine markets across the city centers where agricultural products are kept in ambient conditions and generally exposed to the risk of contamination, especially by molds and other contaminants, does not count for consumer safety. This explained the presence of quantities of rotten peanuts in markets and points of sale where sellers are daily concerned about sorting [15].

5.7. Other factors

There are also other factors that can influence the contamination of groundnut by fungi in DRC : late harvesting of groundnuts in the field, attacks by insects and rodents and unconscious practices of some farmers or other people trained in the processing or packaging of peanuts.

6. MYCOTOXIGENESIS IN PEANUT

The production of mycotoxins by molds is a complex process that is more activated by the composition of food, such as peanuts.

It is probably a reaction of the mold to stressful environmental conditions (temperature, too high or too low humidity) and is mainly governed by environmental factors including water content, temperature, and degree of confinement during the conservation [43].

The synthesis of mycotoxins takes place during the idiophase, which is a phase located after the active phase or the multiplication phase of the fungi. Mycotoxins are not necessary for the survival or multiplication of the fungus. They have 3 origins : amino acids, polyketoacids and terpenes. The different mycotoxin synthesis pathways derive from coenzyme A (CoA). This is then acetylated into a polyketide or polyketoacid via a polyketide synthetase (PKS), to lead to the synthesis of mycotoxins derived from polyketoacids [34] [44] [45].

With high levels of sugar and lipids, oilseeds are very favorable to toxigenesis. The production of aflatoxins by *Aspergillus flavus* ; for example ; is emitted by certain sugars such as glucose, mannose, fructose, and sucrose. Trace elements such as iron, zinc, and copper also contribute to the biosynthesis of aflatoxins and ochratoxins by acting as cofactors for various enzymes involved in their biosynthesis. These trace elements all inhibited the production of these two toxins at concentrations below 10 mg/L of medium and zinc is the one that has the most effect on growth and the production of aflatoxins. The effect of iron and copper may be due to their role as catalysts for lipid peroxidation [23].

7. CURRENT STATE OF RESEARCH ON FUNGI AND MYCOTOXINS CONTAMINATING PEANUTS IN DRC

7.1. Research conducted on fungi

According to the analysis of available data, Aspergillus is the main germ isolated in groundnuts consumed in the DRC. *A. flavus*, *A. parasiticus*, *A. niger*, and *A. fumigatus* appear among the germs most quoted in the contamination of food, and more particularly of groundnut. *A. flavus* is the world's first known mold to produce an incriminated toxin and gave the name to a genus of fungus, Aspergillus. It grows aerobically on ordinary media under conditions of high heat and humidity. Aspergillus is part of the storage or xerotolerant fungi [24].

Already in the 78s, Masimango [46] had confirmed the presence of *A. flavus* and other species such as *A. parasiticus*, *A. niger*, and *A. fumigatus* in the groundnut seeds required in the different provinces of the country (Kinshasa and the former provinces of Equateur, Bandundu, and Orientale), and also in other food, in this case, corn, rice, sweet potato, cassava. Later, Yandju et al., [47] demonstrated the production of aflatoxins by certain Aspergillus, in particular, *A. flavus oryzae, A. flavus, A. niger, A. glaucus cbeualieri* and *A. fumigatus*, during the softening of cassava by dry fermentation in the province Oriental. Similar results were confirmed recently by Masika et al., [48] in the same process of dry cassava fermentation in North Kivu.

In addition, Mulunda et *al*., [49] also isolated *Aspergillus spp* and *A. flavus* in groundnut sold in some markets in Katanga province, in DRC. Kamika and his team counted Aspergillus in 95% of groundnut samples from Kinshasa and Pretoria, respectively around 40-21,000 Colony Formant Unity (CFU) and 20-49,000 CFU per gram of groundnut [50].

In a literature review published by Reddy et al., [22] on the contamination of important agricultural products by mycotoxins across several countries, *A. flavus* and *A. parasiticus* were indexed as major fungal contaminants of groundnut. These results corroborate those reported by Mupunga et al., [51] in "Peanuts, aflatoxins, and undernutrition among children in sub-Saharan Africa".

Similar results have been recorded in other african countries such as Ethiopia [2] [4], Zimbabwe [17], Burundi, South Africa, Zambia [52], and similarly in Nigeria [37], with the exception of Oluwawapelumi, in addition to Aspergillus (*flavus* and *ssp*), isolated other molds (Fusarium, Penicillium) in samples of indicated groundnuts in a few household markets in different agro-ecological zones of Nigeria [53]. This sufficiently proves the cosmopolitan power of these fungi and their susceptibility to contaminate several foods and to excrete mycotoxins. It is also important to note that due to its geocarpic character, other soil fungi can be isolated from rotten and healthy peanut pods and seeds, [35] [54].

7.2. Mycotoxin research

There is very few amounts of research done on the mycotoxins present in groundnut in the DRC [15] [49] [50].

Table 2 : Studies carried out on groundnut mycotoxins in the DRC

Authors	Year	Origin of samples	Types of mycotoxins	Mycotoxin content (pbm)	Reference
Tshibangu	1972	Kinshasa	Aflatoxin B1	330-880	Umba et al.2020
Kabeya	1973	Kinshasa	Aflatoxin B1	10-200	Umba et al.2020
Masimango	1978	Kinshasa	Aflatoxin (AF)	800	Umba et al.2020
Mwanza	2013	Lubumbashi	Aflatoxin OTA	0.25-57 0.14-11.2	Mwanza et al.2013
Kamika	2013	Kinshasa	Aflatoxin B1 Aflatoxin B2 Aflatoxin G1 Aflatoxin G2	219-54393 201-21092 217-31029 230-20193	Kamika et al.2013
Udomkun	2018	Kivu	Aflatoxin B2	448-8320	Udomkun et al.2018

In view of these fragmentary data, Aflatoxins stand out as the main mycotoxins and are mainly found in peanuts after their contamination by molds. Although the quantity of these toxins generally varies in the different agro-ecological zones where samples were collected, their presence in groundnut does not surprise anyone. Otherwise, this presence confirms the systematically identifying aflatoxigenic power of aspergillus, which no longer needs to be demonstrated [47] [48]. This explains the importance of the mycotoxin index in food ; like groundnut ; in order to prevent their very significant impact on human and animal health [21].
In other african countries, several works carried out have confirmed the contamination of groundnut by aflatoxins [52]. In Morocco, Tantaoui-Elaraki and his collaborators report the average level of 250µgkg^{-1} of aflatoxin in peanuts during an analysis of foodstuffs distributed in this country [43]. Similar results were found in Sudan in groundnuts sold in local markets, whereas in Ivory Coast, the average contamination rate of peanuts by aflatoxins B1 is 4.8 µgkg^{-1} and it is below 2 µgkg^{-1} in marketed peanut paste [55] [56] report values of 11.9-15 µgkg^{-1} of total aflatoxins in groundnut in Ethiopia. In Nigeria, Odoemelam and Osu [57] found Aflatoxin levels overlapping around 74.03-82.12 µgkg^{-1} in groundnut samples traded in Niger State. In South Africa, the level of Aflatoxins that is reported in groundnut collected in certain clandestine markets ranges from 0-35.39 µgkg^{-1} [26] and 0.26-131.03 µgkg^{-1} in the food ration for farmers, while in Zimbabwe and Mozambique, this rate is 0-10000 µgkg^{-1} and 6.6-622 respectively in samples from local markets [52].
However, apart from aflatoxins and Ochratoxine A (Ochratoxine A), other mycotoxins are found naturally in groundnuts, such as beauvericin, cyclopiazonic acid, nivalenol, moniliformin, and many others, as identified in Nigeria by Oluwawapelumi and his collaborators [53] and Kayode [58] and in India by Mehan and Mcdonald [35].

8. ANALYTICAL APPROACH TO MYCOTOXINS

Several methods exist to date for measuring mycotoxins in different foodstuffs such as peanuts. Generally, these methods are categorized into two groups : qualitative or rapid screening methods (thin layer chromatography, immunological methods) and methods quantitative such as gas chromatography (GC) or liquid phase (HPLC) sometimes coupled with a mass spectrometer, based on the chromatographic separation of molecules than their detection by fluorimetry or spectrometry. Hence, the mycotoxins present in groundnut must first be extracted and purified before their quantification [34] [59].

9. TECHNOLOGICAL TREATMENTS AND MYCOTOXINS IN PEANUTS

Mycotoxins are thermostable molecules and are not very sensitive to most thermal processes (sterilization, pasteurization, freezing) or drying (dehydration, freeze-drying), with the exception of roasting which reduces the content of aflatoxins by 50 to 80% in peanuts. Processes for extracting oil from peanuts, soybeans, cottonseed, etc. predict the content of aflatoxins (B and G) in the crude oil to be found in large quantities in the meal. It is through subsequent oil refining treatments that these aflatoxins are completely eliminated. For the treatment of meals intended for animal feed, the detoxification process is based on ammonia, whether or not associated with formalin, and more or less 95% of the initial content of aflatoxin B1 is eliminated, but such a procedure cannot be applied to food intended for humans [13].

10. HEALTH EFFECTS DUE TO THE CONSUMPTION OF PEANUTS CONTAMINATED WITH MYCOTOXINS IN DRC

It is very difficult to assess the health impact of the exposure of the Congolese population to the mycotoxins contained in peanuts commonly consumed throughout the country. The lack of data due to the lack of epidemiological research in this area explains this. At the very least, it is necessary to recall that aflatoxins have been the subject of some research carried out on mycotoxins contaminating peanuts sold in the DRC [15] [50]. They are among the most toxic mycotoxins. Pathologically, they are classified as hepatotoxins, nephrotoxins, vomitoxins, and neuromusculotoxins, some of which are formidable carcinogens and mutagens. Aflatoxin B1 is even classified in group I of human carcinogens by the International Agency for Research on Cancer [19] [20] [39] [60] [61].
The prevalence rate of aflatoxins in groundnut and other food (maize, sorghum, cassava, etc.) is high in several African countries, according to the American standard for aflatoxins (20µgKg^{-1}) and the European standard (4 µgKg^{-1}). However, low exposure to aflatoxins can have measurable health effects [62]. Many epidemiological studies, obtained in Africa in particular, have demonstrated the existence of a positive correlation between chronic exposure to aflatoxins via the human diet and the prevalence of primary liver cancer [13] [24] [34] [60] [63].

According to the report of the American National Institute of Health and Environmental Sciences [26], the DRC is among the countries with a high prevalence of liver cancer, as shown in Figure 5.

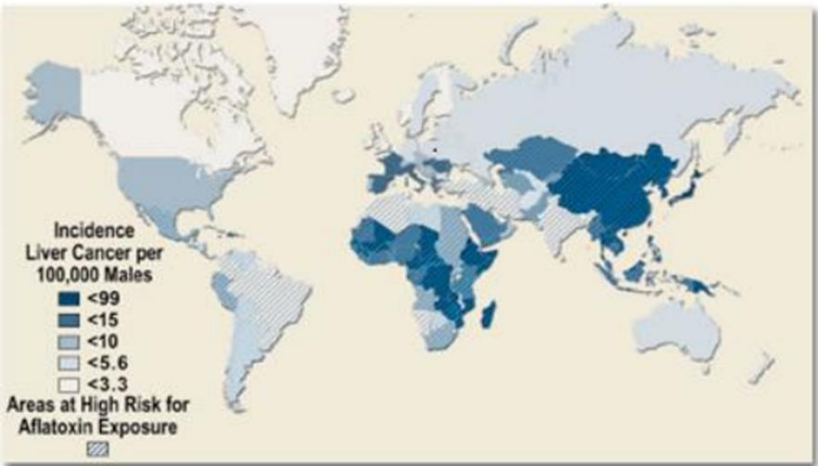

Fig. 7 : Prevalence of liver cancer in relation to exposure to aflatoxins (INSSE)
Source : Kamika, 2012

There is another link between malnutrition/Kwashorkor, stunting, and exposure to aflatoxins. In the human body, Aflatoxins induce immune dysfunction leading to an increased risk of infections and loss of energy, with disturbances in the levulosity of the intestine, leading to poor absorption of nutrients. Furthermore, a growing body of epidemiological data supports the hypothesis that exposure to aflatoxins in the womb has negative effects on newborn growth [64]. However, on the nutritional level, in the DRC, the reports presented by the FAO showed that 43% of the population suffers from chronic malnutrition, in particular children and pregnant and lactating women. Underweight currently affects 23% of children under 5, while 16% suffer from it in schools [7] [8] [9] [10]. It should also be noted that malnutrition, stunting, and gastrointestinal syndrome are health problems encountered throughout sub-Saharan Africa. Such superimpositions of facts in cases are not mere coincidences. However, this in-depth information requires in-depth epidemiological studies within different strains of the population in order to clearly show the impact of food mycotoxin interactions in the organism of the victims.

11. ECONOMIC IMPACT OF AFLATOXINS IN PEANUTS IN DRC

The contamination of agricultural products such as peanuts by mycotoxins is characterized by the modification of the organoleptic characteristics and the rejection of the food, thus causing enormous losses in agricultural production. However, the assessment of the extent of all these losses remains difficult and often partial to determine. Currently, the FAO estimates losses due to contamination and annual food waste at around 20-35% of global production [19] [65]. In the United States, for example, the Council of Agricultural Science and Technology (CAST) generated US$932 million in annual economic losses from agricultural production and US$8.4 million from the effects of mycotoxins on animal health [43]. According to the Partnership for Aflatoxin Control in Africa (PACA), aflatoxins are a major barrier to African farmers' access to markets, as they prevent products from meeting agricultural and food trade regulations and standards of safety. It is estimated that Africa loses $670 million per year in export trade alone due to aflatoxin contamination [62].

For the DRC, the contamination of foodstuffs is visible and intense. The FAO estimates that the country would lose more than 6 million tons of agricultural products out of an annual production estimated at more than 20 million tons [11]. The quantities of rotten groundnuts in the markets bear witness to these losses, which are unfortunately not quantified or provided for lack of data [11] [15]. Other collateral effects that lead to these losses are to be determined, such as the reduction in transactional performance on the groundnut market or the loss of animals fed on contaminated groundnut feed.

12. REGULATION ON FOOD SAFETY

It is FAO's mission to achieve food security for all by ensuring regular and sufficient access to good quality food throughout the world. The Codex Alimentarius is the Joint FAO/WHO Commission responsible for protecting the health of consumers and promoting fair practices in the food trade by setting maximum levels of contaminants and additives in foods or giving other advice on risk management to combat or prevent contamination. The Codex Alimentarius is present in more than 160 countries in the world [50] [66]. However, less than 100 countries have regulations on mycotoxins while almost fifty african countries do not have data.

In the DRC, the Congolese Control Office is the State body responsible for the regulation and control of food and drugs throughout the country, according to Ordinance-Law No. 74-013 of 10 January 1974, supplemented by decree n° 09/44 of 03/12/2009. It determines the quality of agricultural products subject to inspection during import and export, certification of local products, and the exercise of damage control [15] [67] [68]. Other national services such as those of the Ministry of agriculture are also responsible for the health protection of plants and plant products by preventing and combating harmful organisms both at the level of their introduction and their propagation on national territory, according to decree-law no/05-162 of November 19, 2005 [69]. The National Codex Alimentarius Committee, in its role of cordon with the International Codex Committee, exists in DRC, and can beforehand propose certain food codes (standards) adopted at the international level, and at the national level. But to date, the country does not have any specific national law regulating the control of mycotoxins or other contaminants in food throughout the national territory [15] and ranks among the countries where the legislation on mycotoxins is still non-existent, as shown in Figure 9 [66] [70] [71].

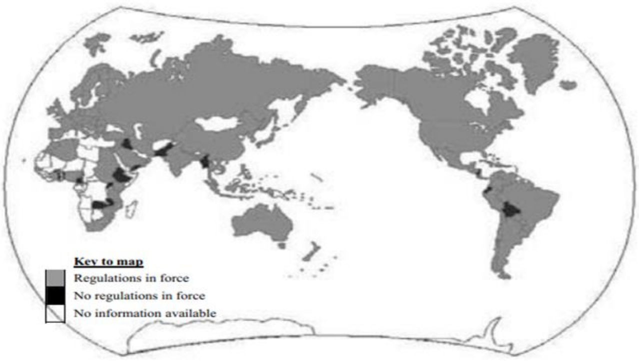

Fig.8 : Classification of countries according to the level of knowledge on mycotoxins and legislation.
Source : [66]

CONCLUSION

The contamination of groundnut by mycotoxins as well as the molds which secrete them remains a great challenge that the world must face and especially the poor countries in the process of development, such as the DRC, with a view to guaranteeing food safety for various consumers.

Peanuts in the DRC are among the most consumed foods because of their nutritional richness and their accessibility by the different layers of the population.

It is also a food very sensitive to contamination by fungi, especially since the environmental conditions (heat and humidity) lead to their development. Aspergillus remains the main fungal contaminant of groundnut. *Aspergillus flavus*, *Aspergillus parasiticus* et *Aspergillus fumigatus* top the list. These germs are mycotoxigenic and more particularly aflatoxigenic. Due to the economic losses associated with their effect on human health, animal productivity, and national and international trade, these mycotoxins have come to our attention. The major challenges that Congolese decision-makers must face in order to guarantee consumer safety and promote the trade of agricultural products, in particular groundnut, by providing the country with a national policy for the management of food mycotoxins.

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