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Aflatoxins and Moisture Levels in Edible Oils Produced in Burkina Faso

Souleymane Zio[1], Isaac Dembele[1], Raoul Sylvain Bazoin Bazié[2], Abel Tankoano[3], François Tapsoba[1], Fatoumata Hama-Ba[3], Laurencia Toulsoumdé Songre-Ouattara[3], Fulbert Nikiéma[2], Driss Elothmani[4], Yves Traoré[1] and Aly Savadogo[1*]

[1]Laboratoire de Biochimie et d'Immunologie Appliquée, Département de Biochimie-Microbiologie, Université Joseph KI-ZERBO, 03 BP 7021 Ouagadougou 03, Burkina Faso.
[2]Laboratoire National de Santé Publique, 09 BP 24 Ouagadougou 09, Burkina Faso.
[3]Département de Technologie Alimentaire, Institut de Recherche en Sciences Appliquées et Technologies, 03 BP 7047 Ouagadougou 03, Burkina Faso.
[4]Laboratoire Grappe, Ecole Supérieure d'Agricultures, Université Bretagne Loire, 55 Rue Rabelais-BP 49100 Angers, France.

Authors' contributions

This work was carried out in collaboration among all authors. Authors SZ and AS designed the study. Author SZ wrote the protocol, wrote the first report of the manuscript, performed the statistical analysis and managed the literature search. Authors SZ, ID and RSBB managed the analyses of the study. Authors AS and YT supervised the study analyses. All authors including authors AT, FT, FHB, LTSO, FN and DE read and approved the final manuscript.

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ABSTRACT

Aim: The study aim was to assess aflatoxin and moisture levels in edible oils produced and consumed in Burkina Faso to know the impact on consumer health.
Methodology: A total of 61 samples of refined cottonseeds oils and crude peanut oils were collected from Ouagadougou, Bobo Dioulasso and surrounding areas. Aflatoxin B1 (AFB1),

**Corresponding author: Email: alysavadogo@gmail.com;*

aflatoxin B2 (AFB2), aflatoxin G1 (AFG1) and aflatoxin G2 (AFG2) were determined by HPLC and moisture by differential weighing after oven drying.

Results: The moisture content of peanut oils were ranged from 0.06 to 0.18% and cottonseeds oils from 0.02 to 0.17%. The moisture average is 0.13% for peanut oils and 0.08% for cottonseeds oils (P<0.05). The moisture of all oils is lower and conform to the *Codex Alimentarius* standard. AFB1, AFB2, AFG1 and AFG2 were identified in 86.89% of the oil samples analyzed. The proportion of samples contaminated with AFB1 is 57.38%, 59.02% for AFB2, 42.62% for AFG1 and 65.57% for AFG2. The AFB1 average of peanut oils is 6.21 ng/g while that of cottonseeds oils is 0.03 ng/g. The AFB2 average of peanut oils is 0.89 ng/g against 0.04 ng/g for cottonseeds oils (P<0.05). The AFG1 average of peanut oils is 0.54 ng/g and 0.08 ng/g for cottonseeds oils (P<0.05). The AFG2 average of peanut oils was 0.66 ng/g against 0.64 ng/g for cottonseeds oils. AFG2 had the highest proportion of all oils while AFB1 has the highest concentration and proportion in peanut oils. The 72.13% samples analyzed in this study comply with the European Community standard for aflatoxin B1 level maximum in oilseeds.

Conclusion: Aside from the moisture content that comply with the standard, aflatoxins are present at varying levels and can negatively impact the consumer health. It is important to strengthen the monitoring and production system in order to have quality oil.

Keywords: Edible oil; aflatoxin; moisture; Burkina Faso.

ABBREVIATIONS

AFB1 : Aflatoxin B1
AFB2 : Aflatoxin B2
AFG1 : Aflatoxin G1
AFG2 : Aflatoxin G2
AFT : Aflatoxin Total
HPLC : High Performance Liquid Chromatography

1. INTRODUCTION

Mycotoxins are secondary metabolites of fungi that can grow on the plant in the field or during harvesting, transport or storage [1]. As a result, mycotoxins are a group of fungal metabolites found in many foods of plant origin including oilseeds. Also, these toxins can accumulate in animal feeds [2]. Edible oils are foodstuffs that contain endogenous and exogenous anti-nutritional factors including mycotoxins [3]. Seeds surface lipids have been shown to be a very important source of carbon for fungal growth [4]. Fat and carbohydrate-rich agricultural products are susceptible to aflatoxin contamination and these raw materials include cereals, rice, leguminous, oilseeds, dried fruit, spices, nuts and animal products [5]. Among the mycotoxins, aflatoxins are an important group, the four main types of which are B1, B2, G1 and G2. Aflatoxins M1 and M2 are metabolites of B1 and B2 that are found in the milk of mammals fed from aflatoxin-contaminated diets. Aflatoxin B1 is a potent hepatocarcinogen and mutagen [6,7]. These contaminants can be found at all levels from oilseed cultivation through refining processes to conservation [8]. However, aflatoxins may be retained in unrefined oils [9]. The presence of mycotoxins has been reported in several vegetable oils worldwide [10,11,12]. In addition, moisture is a factor of edible oils degradation. It leads the development of microorganisms. Thus, it promotes the growth of lipolytic mould species such as *Aspergillus niger*, *Aspergillus tamari* and *Penicillium*, *Paecilomyces* and *Rhizopus* genera which product mycotoxins [13].

In Burkina Faso, the main oilseeds are cotton, shea, peanut and sesame [14]. Since 2003, we have witnessed the emergence of an informal enterprises fabric transforming cottonseeds into edible oils for the local market [15] that are not always conform to the standards of the *Codex Alimentarius* [16] or falsified packaging [17]. In addition, some stakeholders produced and marketed unrefined crude peanut oils using different production technologies [18]. These oils produced and consumed in Burkina Faso have not been assessed for aflatoxin levels. However, the presence of mycotoxins has been reported in various vegetable oils around the world [19,20,21,22,23,24,25]. Hence, the objective of the present study which is to assess the level of aflatoxin and moisture present in cottonseeds oils and crude peanut oils produced in Ouagadougou, Bobo Dioulasso and surrounding areas in Burkina Faso. This work will provide supportive information for the sanitary quality of edibles oils and their impact on the consumer health.

2. MATERIALS AND METHODS

2.1 Reagents and Equipment

All reagents and solvents used for the aflatoxins quantification were HPLC grade. Aflatoxin standards B1, B2, G1 and G2 are Fluka (Sigma-Aldrich) brand. Methanol, Dichloromethane, Hexane, Benzene, Acetonitrile, Hydrogen Chloride, Sodium Chloride are Sigma-Aldrich and Water HPLC grade.

2.2 Instruments

Moisture determination was carried out using an electronic balance, drying in an oven (Memmert) and storage in a desiccator. The aflatoxins were determined by HPLC (Thermo 3000 Ultimate). The HPLC system consisted of a sample injector, a solvent delivery system and both fluorescence and Diode array detectors. This HPLC was connected to a post-derivatization system (Kobra Cell).

2.3 Sample Collection

A total of sixty-one (61) edible oil samples was collected. A volume of 500 mL by sample were collected in amber bottles and sealed, coded, transferred to the laboratory and stored in icebox at ambient temperature for analysis. These samples included crude peanut oils taken from production sites and some markets and refined cottonseeds oils taken from production units based in the Kossodo industrial zone in Ouagadougou-Pabré and Bobo Dioulasso. Specifically, thirty (30) samples of cottonseeds oils 15 samples taken in Ouagadougou-Pabré and 15 samples taken in Bobo Dioulasso were collected. Thirty one (31) samples of crude peanut oils 16 samples were taken in Ouagadougou-Saaba, and 15 samples in Bobo Dioulasso were collected.

2.4 Moisture Determination

Moisture in the oil samples was determined according to the method used by Zio et al. [16]. A mass of 10 g of well homogenized oil sample was weighed into a previously dried and tared crystallizer. The crystallizer was placed in the oven set at 105°C for 1 hour. It was allowed to cool in the desiccator and weighed. Heating was repeated and weighing was carried out under the same conditions with successive stays in the oven for 30 min until the loss of mass of two successive weighing did not exceed 2 mg. At least 2 measurements were made and the arithmetic average of these different measurements was determined. Calculation of the moisture content was carried out as follows: $M\ (\%) = \frac{(m1-m2)}{PE} \times 100$ with m_1 = Mass of crystallizer and oil (g), PE = Test sample (g), m_2 = Mass in g of crystallizer and test sample after drying.

2.5 Aflatoxins Determination

2.5.1 Aflatoxins standards preparation

Mix stock solutions of 5 µg/mL of total aflatoxins in acetonitrile containing 2 µg/mL of Aflatoxin B1, 2 µg/mL of Aflatoxin G1, 0.5 µg/mL of Aflatoxin B2 and 0.5 µg/mL of Aflatoxin G2 purchased from Sigma-Aldrich were used to prepare the working mix solution containing four calibration solutions varying from 2.5 ng/mL-15 ng/mL (Aflatoxin B1), 0.625 ng/mL-3.75 ng/mL (Aflatoxin B2 and G2) and 1.25 ng/mL-7.5 ng/mL (Aflatoxin G1) were injected and the linear regression was used for curve fitting.

2.5.2 Extraction and purification aflatoxins

The AOAC method (970: 40 1990) described by Idris et al. [23] was used with some modifications. The extraction and purification of aflatoxins from the samples taken were carried out as follows: 125 mL methanol water (55:45) was added to 25 g oil sample, then 25 mL 0.1 N hydrogen chloride was added, the mixture was stirred and then filtered. A volume of 25 mL of filtrate was transferred to a 250 mL separator; 25 mL of 10% Sodium Chloride solution was added and shaken. A volume of 25 mL of hexane was added and shaken gently for 5 min. The contents were transferred to a settling flask for 5 min. The lower part containing the aflatoxins was separated in another 250 mL separator in which 37.5 mL of dichloromethane were added and then shaken for 10 min. The mixture is introduced into a settling flask for 5 min. The lower part was introduced into a tube and evaporated to dryness on a boiling water bath for 1h 30 min. The extract was taken up with 1.5 mL methanol and vortexed for 1 min. It was added 0.5 mL distilled water, vortexed for 1 minute and filtered through in vials prior for HPLC analysis.

2.5.3 Determination of aflatoxins by HPLC

The chromatographic conditions used were as follows: a post-column derivatization was used for the aflatoxin analysis. The mobile phase consisted of methanol-acetonitrile-water (3:2:6) containing potassium bromide, a flow rate was

set at 1 mL/min with an excitation wavelength of 365 nm and an emission wavelength of 435 nm. The injected volume was 50 µL. The separation was carried out with Zorbax SB C18 (250x4.6 mm, 5 um) (Agilent Technologies). Aflatoxins were identified by comparison with the retention time of the corresponding standards. Quantification was performed using peak areas.

2.5.4 Statistical analysis

The statistical analysis was performed using Excel 2013 and SPSS Version 20 software. The Fisher test was used to compare the different values obtained at probability thresholds of P=5% (significant if P<0.05 and non-significant if P >0.05).

3. RESULTS AND DISCUSSION

3.1 Moisture Content of the Different Oils

The moisture content of peanut oils collected in Ouagadougou-Saaba cities varied from 0.06 to 0.18% with an average of 0.12%. For the Bobo Dioulasso city, the peanut oils values were varied from 0.08 to 0.17% with an average of 0.13%. The variation between the peanut oils averages is non-significant (P>0.05). For refined cottonseeds oils, the values ranged between 0.02 and 0.13% for cottonseeds oils samples from the Ouagadougou-Pabré city with an average of 0.07%. For cottonseeds oils produced in Bobo Dioulasso, the values ranged from 0.03 to 0.17% with an average of 0.09%. The averages of cottonseeds oils produced in Ouagadougou-Pabré and Bobo Dioulasso are statistically non-significant (P>0.05). All values are in accordance with the *Codex Alimentarius* standard for edible oils with a maximum moisture content not to exceed 0.2% [26].

The different values obtained for the moisture content of cottonseeds oils and peanut oils in Ouagadougou, Bobo Dioulasso cities and arounds are presented in Table 1. Overall, for the different cities, the peanut oils values range from 0.06 to 0.18%, while for cottonseeds oils the averages vary from 0.02 to 0.17%. The averages are respectively 0.13 and 0.08% for peanut oils and cottonseeds oils produced in the different cities (P<0.05). This difference could be due to the manufacturing processes of the oils, which are different. Indeed, cottonseeds oils are refined oils whereas peanut oils are crude oils produced in the traditional process. Also, other factor accountable the difference is the sought objective by the producers of crude peanut oils [18]. Their aim concerns both the production of the by-products and a cake called in local language "*Koura-Koura*" and the oils which are sold in cities. However, all oils analyzed comply with the *Codex Alimentarius* standard permissibility level for moisture content which should be less than 0.2% [26]. This compliance indicates that despite the difference in production between cottonseeds oils and peanuts oils, the drying process is mastered. The moisture average of peanut oils obtained in this study is higher than the 0.05% but those cottonseeds oils is lower than the 0.06% reported by Zio et al. [16]. Also, the peanut oils average is lower than the 0.43% obtained by Soumanou et al. [27]. Finally, our average moisture content of cottonseeds oils is lower than the average 0.09% found by Koudougou and Dicko [17] but higher than the value 0.06% of Soumanou et al. [27]. Water is involved in the degradation for edible oils leading to acidification and the development of microorganisms. Therefore, according to Ribier and Rouzière [28], the water and volatile matter content must be reduced as much as possible because it is responsible for the rapid degradation of oils (rancidity in less than a month). In addition, it is stressed that no microbial multiplication is possible in the absence of water. Anhydrous vegetable oils and fats do not pose any problem of microbiological stability [29].

3.2 Aflatoxins in the Oils Analyzed

The aflatoxins levels in peanut oils and cottonseeds oils produced in Ouagadougou, Bobo Dioulasso cities and around were assessed. Fig. 1 shows the quantity and percentage of samples contaminated with aflatoxins. AFB1, AFB2, AFG1 and AFG2 were found in 86.89% oil samples. Compared to other studies, Elzupir et al. [22] reported 98.8% oil samples analyzed were contaminated by aflatoxins [22]. The proportion of samples contaminated by AFB1 is 57.38%. Specifically, 100% of peanut oils and 13.33% of cottonseeds oils are contaminated by Aflatoxins B1. The proportion of peanut oils contaminated by AFB1 in this study is identical to the proportions found by Sun et al. [30] in China; Abalaka [19] in Nigeria but higher than the 52.4% reported by Elzupir et al. [22], the 48.4% of Yang et al. [31], the 66.7% of Wang et al. [32] and the 80% of Shephard [33] in Senegal. In the Idris et al. [23] work, a proportion of 14.30% of the total samples were contaminated by AFB1 and none refined cottonseeds oils samples were contaminated.

A proportion of 59.02% of oils analyzed (Cotton and Peanut) are contaminated by AFB2, i.e. 96.77% of peanut oils contaminated against 20.0% for cottonseeds oils. The AFB2 proportion in peanut oils is lower than the 100% obtained by Abalaka [19] but higher than the 60.0% of Diourbel in 1998 and 30% of Kaolack in 1997 obtained in Senegal [33] and 66.7% obtained by Elzupir et al. [22]. The proportion of samples contaminated by AFG1 is 42.62% with 10% for cottonseeds oils contaminated compared to 74.19% for peanut oils samples. The proportion of 74.19% of peanut oils samples contaminated with AFG1 is lower than the 95.2% found by Elzupir et al. [22] but higher than the 30.0% of Diourbel in 1998 and the 50.0% of Kaolack in 1988 in Senegal [33]. For AFG2, 65.57% of the oil samples analyzed were contaminated with 73.33% for cottonseeds oils and 58.06% for peanut oils. The proportion of peanut oils samples contaminated with AFG2 in this study is higher than the 33.3% of refined peanut oils [19]; the 25.0% and 30.0% obtained respectively from Diourbel and Kaolack cities in Senegal [33]. However, our proportion of peanut oils is lower than the 100% of crude peanut oils in Nigeria [19]. Overall, the aflatoxins proportion of peanut oils and cottonseeds oils from the highest to the lowest is AFG2-AFB2-AFB1-AFG1. Specifically, the order of the highest to lowest proportion is AFG2-AFB2-AFB1-AFG1 for refined cottonseeds oils and AFB1-AFB2-AFG1-AFG2 for crude peanut oils. AFB1 is the most dominant in crude peanut oils versus AFG2 for refined cottonseeds oils.

The aflatoxins values of the different cottonseeds oils and peanut oils samples are given in Table 2.

AFB1 contents of peanut oils are between 0.39 and 25.32 ng/g with an average of 8.32 ng/g for the oil samples collected in Bobo Dioulasso city. For Ouagadougou-Saaba cities, the AFB1 value vary from 0.07 to 28.31 ng/g with an average of 4.25 ng/g. The AFB1 value of peanut oils samples is not statistically significant (P>0.05). As regards cottonseeds oils produced in Bobo Dioulasso, the AFB1 values vary from 0 to 0.57 ng/g with an average of 0.06 ng/g. Those from Ouagadougou-Pabré were ranged from 0 to 0.11 ng/g with an average of 0.007 ng/g. The

Table 1. Moisture averages of oil samples analyzed by type and cities

Group/Type	Cities	Sample number	Average (%)	F	*P*-Value
Peanuts oils	Ouagadougou-Saaba	16	0.12 ± 0.03	0.52	0.47
	Bobo Dioulasso	15	0.13 ± 0.02		
Cottonseeds oils	Ouagadougou-Pabré	15	0.07 ± 0.03	1.59	0.21
	Bobo Dioulasso	15	0.09 ± 0.05		
Peanuts oils	Ouagadougou-Saaba and Bobo Dioulasso	31	0.13 ± 0.02	20.20	0.00
Cottonseeds oils	Ouagadougou-Pabré and Bobo Dioulasso	30	0.08 ± 0.04		
Sample total / codex standard		61	0.2	-	-

Average ± Standard deviation. F = F of Fisher; Value of P (significant if P<0.05 and not significant if P>0.05). The average moisture content of the different types of oils, the production sites and the number of samples analyzed are detailed

Table 2. Averages and range of different aflatoxins and number of samples by oils types

Oils types	Aflatoxin	Sample number	Range (ng/g)	Average (ng/g)
Peanut	B1	31	0.07-28.31	6.21 ± 7.83
	B2	31	0-3.91	0.89 ± 1.09
	G1	31	0-3.50	0.54 ± 0.79
	G2	31	0-7.92	0.66 ± 1.56
	Total (B1+B2+G1+G2)	31	0.17-35.33	8.32 ± 9.43
Cottonseeds	B1	30	0-0.57	0.03 ± 0.12
	B2	30	0-0.44	0.04 ± 0.10
	G1	30	0-1.99	0.08 ± 0.36
	G2	30	0-3.99	0.64 ± 0.88
	Total (B1+B2+G1+G2)	30	0-6.55	0.81 ± 1.31

Average ± Standard deviation of different averages

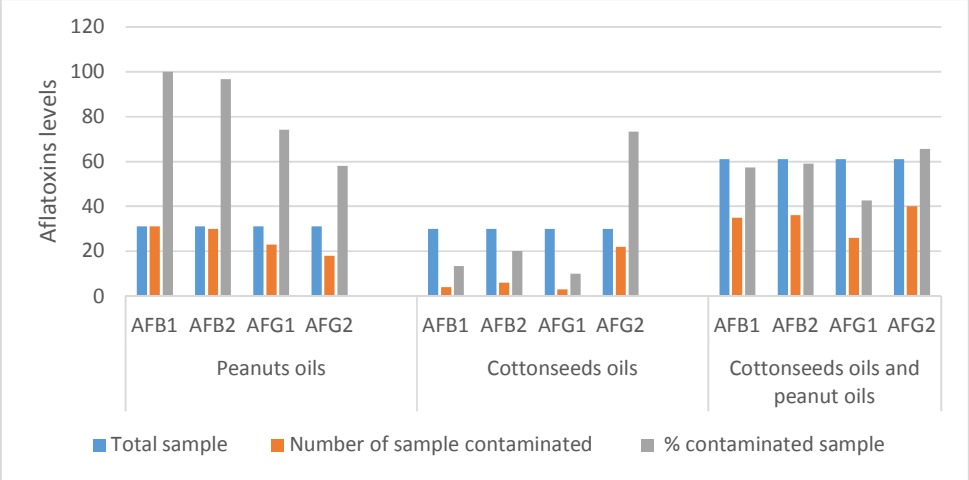

Fig. 1. Percentage of samples contaminated against aflatoxin types (peanut oil concern Ouagadougou-Saaba and Bobo Dioulasso and cottonseeds oil in Ouagadougou-Pabré and Bobo Dioulasso)

AFB1 average of cottonseeds oils produced in Bobo Dioulasso and Ouagadougou-Pabré is not significant (P>0.05). The AFB1 average of peanut oils samples is 6.21 ng/g while that of cottonseeds oils is 0.03 ng/g with a non-significant statistical variation between the oils samples of different cities (P>0.05). The AFB1 average (6.21 ng/g) of peanut oils is higher than the 0.6 µg/Kg found by Idris et al. [22]; the 3.7 µg/Kg reported by Sun et al. [30] but lower than the average (16.3 µg/Kg) obtained by Elzupir et al. [22]. Our AFB1 average (6.21 ng/g) is lower than the 7.8 µg/Kg reported by Wang et al. [32]; the 59.1 µg/Kg of Diourbel in 1997 and 41.6 µg/Kg of Kaolack in 1998 in Senegal [33]. Also, the 6.21 ng/g of this study is lower than the 20.5 µg/Kg of crude peanut oils and the 6.6 µg/Kg of refined peanut oils reported by Abalaka [19] from different production factories of Nigeria. However, Idris et al. [23] did not detect any AFB1 in cottonseeds oils. In contrast, Abalaka [19] reported an average of 11.5 µg/Kg in crude cottonseeds oils but AFB1were not detected in refined cottonseeds oils. The average of peanut oils analyzed for AFB1 is above the European Union Commission maximum limit of 2 µg/Kg in oilseeds [31]. In France, for example, the opinion of the Higher Council of Public Hygiene sets the limit for AFB1 at 5 µg/kg [29].

The AFB2 content in peanut oils produced in Bobo Dioulasso is between 0.14 ng/g and 3.26 ng/g for an average of 1.10 ng/g. The AFB2 values of peanut oils produced in Ouagadougou-Saaba vary from 0 to 3.91 ng/g for an average of 0.69 ng/g. The variation between the AFB2 averages of different cities is non-significant (P>0.05). The AFB2 content of cottonseeds oils produced in Bobo Dioulasso vary from 0 to 0.44 ng/g with an average of 0.06 ng/g. The values of cottonseeds oils produced in Ouagadougou-Pabré range from 0 to 0.23 ng/g with an average of 0.01 ng/g. Overall, the average variation between the cities for cottonseeds oils value is non-significant (P>0.05). The average AFB2 of peanuts oils from Bobo Dioulasso and Ouagadougou-Saaba is 0.89 ng/g against 0.04 ng/g for cottonseeds oils produced in Ouagadougou-Pabré (P<0.05). The average of peanut oils (0.06 ng/g) of this study is lower than the 16.4 µg/Kg obtained by Abalaka [19], the 14.1 µg/Kg of Diourbel in 1997 and 13.5 µg/Kg of Kaolack in 1998 reported by Shephard [33]. On the other hand, Idris et al. [23] did not detect any AFB2 in the peanut oils and cottonseeds oils samples analyzed. The cottonseeds oils average (0.01 ng/g) found in this study is lower than the value 6.95 µg/Kg reported for crude cottonseeds oils by certain authors. The same authors are not detected AFB2 in refined peanut oils [19]. This justifies the indispensable role of refining process to remove undesirable compounds from oils.

The AFG1 values range from 0 to 3.50 ng/g for peanut oils produced in Bobo Dioulasso with an average of 0.70 ng/g. For peanut oils produced in Ouagadougou-Saaba, values range from 0 to 2.37 ng/g with an average of 0.39 ng/g. The correlation between the AFG1 averages of the oils is statistically non-significant (P>0.05). For cottonseeds oils produced in Bobo Dioulasso, AFG1 values vary from 0 to 1.99 ng/g with an

average of 0.17 ng/g. The AFG1 was not detected in cottonseeds oils produced in Ouagadougou-Pabré. The AFG1 averages of cottonseeds oils are not statistically significant (P>0.05). The AFG1 average of peanut oils produced and sold in Bobo Dioulasso and Ouagadougou-Saaba is 0.54 ng/g against 0.08 ng/g for cottonseeds oils produced in Bobo Dioulasso and Ouagadougou-Pabré (P<0.05). The AFG1 average of peanut oils (0.54 ng/g) is lower than the value12.9 µg/Kg obtained by Elzupir et al. [22]; the value 15.9 µg/Kg reported by Abalaka [19]; and the values of Diourbel (8.9 µg/Kg) in 1997 and Kaolack (7.4 µg/Kg) in 1998 [33]. Idris et al. [23] did not identify AFG1 in the peanut oils and cottonseeds oils analyzed. However, an average of 8.4 µg/Kg of AFG1 was found in crude cottonseeds oils [19]. A different and uncontrolled refining process could be at the origin of these dissimilar values.

The AFG2 has been identified in the different oils. Values range from 0 to 7.92 ng/g with an average of 1.19 ng/g for peanut oils produced in Ouagadougou-Saaba. The peanut oils produced in Bobo Dioulasso have AFG2 values ranging from 0 to 1.50 ng/g with an average of 0.10 ng/g. The variation is statistically non-significant (P>0.05). The values of cottonseeds oils produced in Ouagadougou-Pabré are between 0 and 1.43 ng/g with an average of 0.53 ng/g. As regards the cottonseeds oils produced in Bobo Dioulasso, the values range from 0 to 3.99 ng/g with an average of 0.75 ng/g. The AFG2 averages of cottonseeds oils of these cities are statistically non-significant (P>0.05). The AFG2 average of peanut oils produced in Bobo Dioulasso and Ouagadougou-Saaba is 0.66 ng/g compared to 0.64 ng/g for cottonseeds oils produced in Bobo Dioulasso and Ouagadougou-Pabré (P>0.05). The peanut oils average of this study (0.66 ng/g) is lower than those (11.6 µg/Kg) obtained by Elzupir et al. [22]; the 11.8 µg/Kg of Abalaka [19]; the averages of Diourbel (6.1 µg/Kg) in 1998 and Kaolack (1.7 µg/Kg) in 1998 [33]. Idris et al. [23] did not detected AFG2 in the crude and refined peanut oils as well as in the crude cottonseeds oils and refined cottonseeds oils analyzed. The average 0.64 ng/g of cottonseeds oils found for this study is lower than the 7.35 µg/Kg reported in different production factories in Nigeria [19].

The total aflatoxin (B1+B2+G1+G2) levels in vegetable oils samples were assessed. Values ranged from 0.17 to 35.33 ng/g with an average of 6.93 ng/g for peanut oils produced in Ouagadougou-Saaba. The total aflatoxin (AFT) level ranged from 0.70 to 31.15 ng/g with an average of 10.22 ng/g for crude peanut oils produced in Bobo Dioulasso. The variation of the averages is statistically non-significant (P>0.05). For cottonseeds oils produced in Ouagadougou-Pabré, the values vary between 0 and 1.43 ng/g with an average of 0.56 ng/g. The values vary from 0 to 6.55 ng/g with an average of 1.06 ng/g for cottonseeds oils produced in Bobo Dioulasso. The averages are statistically non-significant (P>0.05). The overall AFT average for peanut oils produced in Ouagadougou-Saaba and Bobo Dioulasso is 8.32 ng/g compared to an average of 0.81 ng/g for cottonseeds oils produced in Bobo Dioulasso and Ouagadougou-Pabré. The variation between the averages is very significant (P<0.05). This difference is due to the refining process. Indeed, cottonseeds oils are refined whereas peanut oils are crude oils. Compared to other studies, the average 8.32 ng/g of this study is lower than those obtained for crude peanut oils (64.64 µg/Kg) and refined peanut oils (11.4 µg/Kg) [19]. Elzupir et al. [22] reported a higher AFT value in the order of 32.0 µg/Kg in peanut oils. For cottonseeds oils, our AFT average (0.81 ng/g) is lower than the averages 31.1 µg/Kg and 37.3 µg/Kg of unrefined cottonseeds oils obtained in Nigeria [19]; the values of Diourbel (59.6 µg/Kg) in 1998 and Kaolack (64.2 µg/Kg) in 1998 [33]. The AFT average 8.32 ng/g for crude peanut oils found in this study are above the European Union Commission standard permissibility level (4 µg/Kg) for oilseeds [34]. Fig. 2 shows the chromatograms indicating the presence of aflatoxins in the cottonseeds oils and peanut oils studied.

The majority of cottonseeds oils and peanut oils analyzed are contaminated with aflatoxins. This is corroborated with studies by several authors that have confirmed the presence of aflatoxins in tree nuts, peanuts, maize, cottonseeds and other oilseeds [35]. These aflatoxins are found in oils. In fact, aflatoxins have been reported in several vegetable oils including peanuts oils and cottonseeds oils [22,19,23,33]. The high values of AFB1 and AFT of peanut oils above the European Union Commission standard permissibility level for oilseeds could be related to the high level of seeds contamination and the oils refining process unrealized. In this study, AFG2 had the highest proportion in the different oils analyzed while AFB1 had the highest concentration and proportion for peanut oil samples contaminated. This presence has been

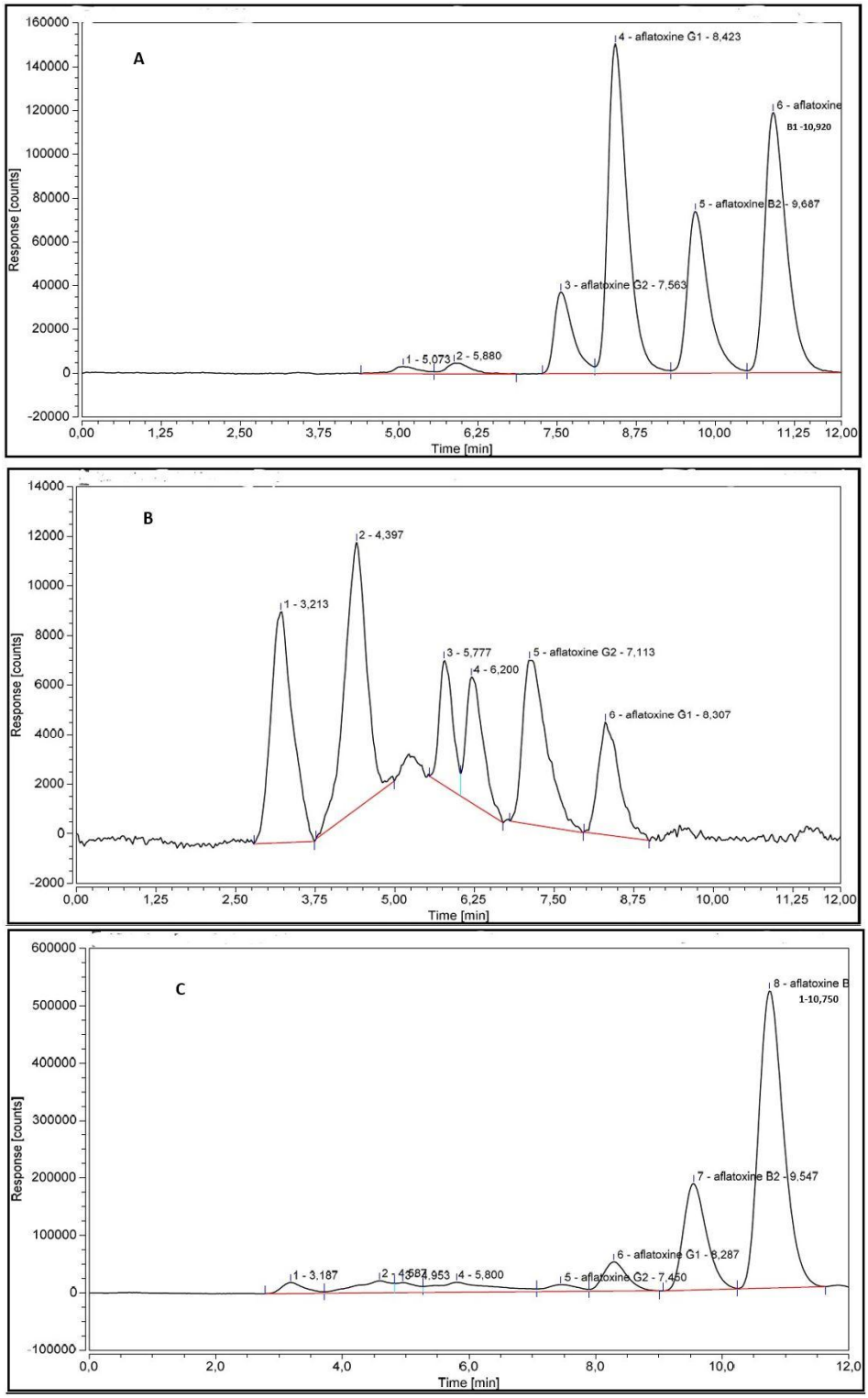

Fig. 2. Chromatograms of some oil samples

A: aflatoxins standards; B: chromatogram of cottonseeds oil sample; C: chromatogram of peanut oil sample. Using the chromatogram of the standards, the different aflatoxins were identified on the basis of retention times

confirmed by Younis et Malik [36] who state that AFB1 is predominant in peanuts and peanuts products. Also, AFB1 is the most toxic of the four aflatoxins (AFB1, AFB2, AFG1, AFG2) [37] and carcinogenic to humans as it is classified as Group 1A [31].

Maximum levels of mycotoxins in food and feed not to be exceeded have been accepted but vary from country to country [38]. However, there are no legal limits for aflatoxins in all edible oils, although they have been set in oilseeds, i.e. 2.0 µg/kg for AFB1 and 4.0 µg/kg for the sum of the four aflatoxins (B1+B2+G1+G2) [39]. In view of their hazard to the health of the consumer, it is possible to eliminate them.

From the standard conforming viewpoint, 100% refined cottonseeds oils are conform Commission of European Community standard permissibility level for aflatoxin B1 (2 µg/kg) in oilseeds. For total aflatoxin level, 96.66% refined cottonseeds oils are conform Commission of European Community standard (4 µg/kg) in foodstuffs while all cottonseeds oils are conform United States Food and Drug Administration standard (20 µg/kg) in human foodstuffs. Our results are similar to refined cottonseeds oils obtained by Idris et al. [23]. For crude peanut oils, 45.16% of oils analyzed comply with the Commission of European Community standard for aflatoxin B1 level (2 µg/kg) in oilseeds against 54.84% non-compliance. For total aflatoxin, 48.38% oils analyzed complied with the Commission of European Community standard for total aflatoxin (4 µg/kg) foodstuffs versus 87.09% for refined cottonseeds oils complying with the United States Food and Drug Administration standard (20 µg/kg) for foodstuffs. The significant aflatoxins presence in peanut crude oils is believed to be unrefined oils and poor quality seeds. Values from this study are superior to that reported by Idris et al. [23]. In general, 72.13% oil samples analyzed in this study comply with the Commission of European Community standard for aflatoxin B1 level maximum (2 µg/kg) in oilseeds. The same proportion in oils analyzed is observed for total aflatoxin at Commission of European Community maximum level (4 µg/kg) in oilseeds compared to 93.44% oil samples complying with the United States Food and Drug Administration food standard.

As generally observed, the aflatoxins level elevated above the standards constitutes a danger for consumers. This expose consumers to certain pathologies. Crude peanut oils used in this study had higher average aflatoxin levels than refined cottonseeds oils. All aflatoxin concentrations (B1, B2, G1 and G2) in crude peanut oils are higher than cottonseeds oils. Thus, aflatoxin B1 average of peanut oils is higher than refined cottonseeds oils. This could be related to high levels contamination of peanut seeds and the refining process unrealized. Refining is essential to remove edible oils undesirable compounds. Aflatoxins are removed during the steps of a conventional chemical refining process: the action of soda ash during neutralization destroys 90 to 98% of them; the residue is removed during discoloration [28]. The use of UV radiation as a detoxifying agent for peanut oil has recently aroused interest [33]. This has been proven by the use of solar radiation, which is well suited to artisanal peanut oils packaged in transparent glass bottles in the case of aflatoxin. Aflatoxins are undetectable after two days of exposure to the sun, without altering the physico-chemical parameters. Another technical, the addition to oils of clays such as bentonite or attapulgite are likely to complex aflatoxin energetically [40]. Finally, it is also necessary to use high quality raw materials or reduce the level of aflatoxins in contaminated peanuts before oils extraction by conventional means, such as bleaching and sorting [33].

4. CONCLUSION

The present investigation allowed the moisture and aflatoxins determination in refined cottonseeds oils and crude peanut oils produced and consumed in Burkina Faso. The moisture of all oils is lower and conform to the *Codex Alimentarius* standard. For aflatoxins, a proportion 86.89% of the oil samples analyzed were contaminated. Aflatoxin B1 is the most dominant in crude peanut oils against aflatoxin G2 in refined cottonseeds oils. A rate of 72.13% of oil samples analyzed comply with the Commission of European Community standard permissibility level for aflatoxin B1 in oilseeds. The same proportion is observed for total aflatoxin in oils analyzed. Peanut oils are the most contaminated. Therefore, the oils production technology requires special attention to obtain a quality oil free aflatoxins, especially peanut crude oils. Aflatoxins presence in vegetable oils can negatively affect the consumer health. Refining must be applied normally. Indeed, oils refining is essential because it reduces the moisture content, prevents the growth of lipolytic mould species and removes

contaminants such as aflatoxins. It is necessary to use good quality oilseeds for oils production. Also, it is important to strengthen the monitoring and production system in order to have quality oil.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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