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ASSESSMENT OF THE RISK FACTORS ASSOCIATED WITH AFLATOXIN CONTAMINATION DURING THE MARKETING OF PEANUTS IN CÔTE D'IVOIRE

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Abstract: *This study was conducted to assess the different risk factors related to practices of sale of peanuts for better control of aflatoxin contamination and also to improve the safety of peanuts during marketing. The sales practices are similar regardless of the area surveyed. Of all the respondents in this survey, 61.7% were men as against 38.3% women and 70% of the respondents do not have any formal education. The marketing of peanut seeds is generally an activity done by men (100%) while that of peanut paste is assigned to women (100%). The unsold peanut paste is kept from 1 day to 3 months at room temperature until sale, mainly in market stalls used to sell it (42.4%) or in stores (39.4%). The losses are mainly due to fungi (37.9%) and insects (13.6%) followed by humidity and high temperature (4.5%). During sale of peanut paste, the site, the surroundings of sales points and the storage containers are potential fungi growth factors and eventual risk points for mycotoxin contamination. Proper handling and hygiene might reduce the aflatoxin contamination of peanut to ensure better sanitary quality of peanuts and protect consumer's heath.*

Keywords*: mycotoxins, sale, market, peanut, risk.*

1. Introduction

Native to the Caribbean area, peanut (Arachis hypogaea L.) is a major food source [1]. In Africa, peanuts represent a major cash crop that contributes significantly to food security and poverty reduction [2, 3]. This oilseed is very rich in protein (25%) and lipid (50%) and it is thus an important nutrient source for populations [4].

In Côte d'Ivoire, peanuts are mainly produced in the center and north regions [5]. However, their production is not self-sufficient. The totality of Ivorian production is entirely meant to self-consumption [6]. In Côte d'Ivoire, peanut is a staple food used for oil production but also for paste produced from roasted seeds [6]. Peanut paste is widely used in the preparation of soup but also as a spread [7]. In Côte d'Ivoire, peanut paste is

traditionally produced and marketed under unsanitary conditions [8].

Like most crops, peanut production and marketing face losses caused by insects and rodents, but also contamination by mycotoxins produced by toxinogenic fungi. Contamination of food by toxinogenic fungi and their mycotoxins has been recognized by the World Health Organization as a major source of food-borne diseases [9].

Mainly produced by Aspergillus genus, including Aspergillus flavus, Aspergillus parasiticus and Aspergillus nomius, aflatoxins are the main mycotoxins commonly associated with peanuts. Aflatoxin contamination of peanuts may occur before harvest, during storage and during marketing [10]. Numerous studies have reported that contamination of peanuts sold on markets by Aspergillus and aflatoxins, in Côte d'Ivoire [11], Congo [12] and Ethiopia [10].

Aflatoxins are highly toxic, mutagenic, immunosuppressive, teratogenic and carcinogenic which target primarily the liver [13, 14]. Aflatoxins are thermostable and it is thus difficult to eliminate them from food. However, studies have shown that foods contaminated with aflatoxins can be detoxified by using inorganic salts, organic acids, ammonia, and aflatoxin B1 binding agents [14]. According to Elmore et al. [15], African cooking courses such as heat treatment and fermentation cannot reduce aflatoxin contamination to an acceptable level. In contrast, some processing methods such as roasting could significantly reduce aflatoxin levels by 89% in the final product [14].

Aflatoxin contamination does not only limit exports to the European countries due to the application of standards, but it also reduces the revenue of peanut producers and represents a risk for consumer's health. The establishment and control of good hygiene practices and production could help to limit aflatoxin contamination. This study aims to contribute to control aflatoxin contamination during the sale of peanuts and derivate products on the Ivorian markets by the determination of sales practices.

2. Matherials and methods

2.1. Material

Study sites. The study was carried out in four major cities of Côte d'Ivoire, namely, Abidjan, Bouaké, Korhogo and Daloa which represent the main food supply areas respectively in the southern, central, northern and western areas of the Côte d'Ivoire. Abidjan, the economic capital of Côte d'Ivoire is the largest consumer market. Bouaké, the second city of Côte d'Ivoire has a leading role in marketing since it is a food collect and exporting centre. Daloa is the centre for food products collection in the western region and Korhogo a food collect for the north. Figure 1 shows the location of these study areas.

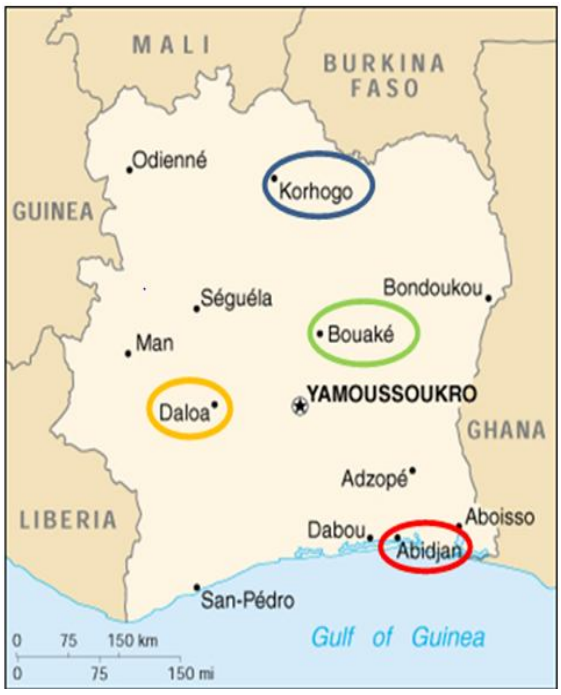

Fig. 1. Map of Côte d'Ivoire showing sample collection areas for rice, maize and peanut

2.2. Methods

Survey. A socio-demographic survey was conducted in the main markets belonging to the cities of Abidjan (26), Bouaké (10), Korhogo (13) and Daloa (11). The study population of 60 sellers consisted of 3 types of sellers mainly unshelled peanut sellers (8), grain wholesalers (38) and peanut paste sellers (20) which means wholesalers, retailers and peanut paste sellers.

The sales conditions were investigated and direct interview was conducted to identify the characteristics of the sellers (sex, age, educational status, methods of supply, duration and storage conditions, conditions of the peanut paste production, loss or deterioration, management of the unsold peanut paste etc.).

Statistical analyses. The data obtained on the characteristic of the sellers and the handling of peanut during selling were submitted to an analysis of SPSS Statistics Version 21, using Khi-deux Pearson test with respect to the conditions of peanut sale investigated during aflatoxin risk factors assessment.

3. Results and discussion

Socio-demographic profile of traders is shown in Table 1. 61.7% of all in this survey were men. The result of this study is different from that of Mutegi et al. [16] who, in a similar study in Kenya, found that only 25% of peanut sellers were men. The age of traders ranged between 15 and 60 years old or more, with a majority (85%) between 30 and 60 years old (Table 1). While peanut seed sale is exclusive to men between ages of 30 and 60, women only make the peanut butter sale. According to the respondents, seed trade requires a lot of money, which explains why this activity is done by men. In addition, 70% of traders surveyed have no level of study. In addition, only 1.7% has a high level of education (Table 1). These results corroborate those of Boli et al. [17] who, after a study of the main markets of the city of Abidjan, reported that 73.4% of peanut paste sellers are illiterate. The peanut trade therefore does not require a specific level of study. However, this lack of education could affect knowledge and the need to use good production practices.

Table 1.

Socio-demographic profile of peanut traders interviewed

Socio-demographic profile	Number of individuals (n=60)	Percentage (%)
Locality		
Bouaké	10	16.7
Korhogo	13	21.7
Daloa	11	18.3
Abidjan	26	43.3
Sex		
Male	37	61.7
Female	23	38.3
Age		
15-30 years	4	6.7
30-60 years	51	85.0
> 60 years	5	8.3
Level of education		
Primary	13	21.7
Secondary	4	6.7
Superior	1	1.7
None	42	70.0

Practices and forms of peanut marketing. Table 2 showed that the majority of traders are independent (91.7%), most of them (70%) having more than 20 years of experience in the field and with peanut sale as their main source of revenue (63.3%). This could be explained by the fact that most traders inherit a family business. They have learned for most part, the trade since childhood, as evidenced by the number of experience years. Similar observations were made by Broutin and Rouyat [18] who indicated that in urban areas, the majority of food processors and sellers benefit from the support of family members who replace them during their periods of inactivity.

Table 2 also showed that peanuts are marketed in several forms. The main forms are seeds (63.3%), followed by paste (30%) and dried pods (11.7%). Fresh pods are the least marketed at 6.7%. However, it is important to mention that peanuts are sometimes marketed at the same time with cereals such as maize (46.7%), rice (38.3%), millet (16.7%) and cashew (8.3%).

Peanuts are mainly marketed as shelled seeds or paste. They are often marketed on the same display as other cereals such as maize and millet, which could lead to cross contamination between peanuts and other marketed products.

Table 2.

Practices and forms of peanut marketing in Côte d'Ivoire

	Number of individuals (n=60)	Percentage (%)
Trader type		
Independent	55	91.7
In association	5	8.3
Years of experience in peanut trade		
1-10 years	10	16.7
10-20 years	8	13.3
> 20 years	42	70.0
Main source of revenue		
Yes	38	63.3
No	22	36.7
Forms marketed*		
Fresh pods	4	6.7
Dried pods	7	11.7
Shelled seeds	38	63.3
Peanut paste	18	30.0
Other commercialized products*		
Rice	23	38.3
Corn	28	46.7
Cashew	5	8.3
Mil	10	16.7
Bean	4	6.7
Sorghum	2	3.3
Bambara peanut	1	1.7
Pistachio	1	1.7

(n) = number of individuals surveyed

*Proportions sum is greater than 100% because only one person can have more than one choice for this question

Sales circuit and storage mode. Table 3 highlights the sale circuit and storage methods for pods, seeds and peanut paste. Peanut trade in Côte d'Ivoire uses the same circuit regardless of the zone and the type of interviewed traders. The sales circuit takes into account several actors including, farmers, trackers, wholesalers and semi-wholesalers. In the sale circuits, it appeared that 39.4% of traders obtained peanuts from wholesalers, 27.3% from farmers, while 27.3% were self-supplied. It should be noted that the trackers (1.5%) intervened very little in this circuit (Table 3). Trackers, wholesalers and semi-wholesalers systematically scour villages for field buying of cereals and other food products. This trade circuit differs very little from that established by Demont [19] on marketing systems for food products (maize and peanuts) in Côte d'Ivoire. From tracker to wholesaler and retailer, peanut undergoes transport and storage times that can promote fungi proliferation.

In 68% of cases, peanuts sold in Ivorian markets can be kept for a period varied from one day to three months regardless of storage location at room temperature, mainly in markets (42.4%) and in warehouses (39.4%). For reasons of profitability and according to the market demand, traders keep the same stock until it is completely exhausted before buying a new one. Similar results obtained by Boli et al. [17], in Abidjan markets, showed that peanut paste could be marketed over a period of 3 months. Peanuts pods and/or seeds are either stored in polythene bags (45.5%) or in aluminium bowls for peanut seeds (24.2%) or paste (35%) and in plastic pots with lids only for peanut paste (85%). These results are consistent with those of Xu et al. [20]. According to them in a similar study in Gambia, most women reported using sealed plastic containers (40%) or bags (44%), or a combination of both to store their peanuts.

In addition, the risk to peanut paste contamination with aflatoxins increases with the duration of marketing due to bad practices and many manipulations [21]. The conditions and duration of peanut storage in our markets represent a risk of increased contamination of peanuts by aflatoxins.

Causes of losses and quality control of peanuts. The majority of traders (48.5%) said they did not have any losses during peanut sale. About 36.4% of traders suffer losses of 2 to 50% during sale. These losses could be explained mainly by the action of fungi (37.9%) and insects (13.6%). About 50% of the respondents have already observed peanut contamination by fungi. The results of this study confirm those of other authors where losses were also recorded after long periods of peanut storage. As examples, in Benin losses of 2 to 5% have been recorded [22] and 5 to 15% in Ghana [23] after a sorting in view to eliminate mouldy seeds.

However, the majority, 74.2% of interviewed traders, did not use any ways of control. The mains means of control to reduce losses was drying and sorting. The choice of these methods could be justified by the lack of education of majority of traders and absence of training in good hygienic practices. These results corroborate with those obtained by Mutegi et al. [16] who indicated that the main control methods are sorting, drying and sieving. Some traders (wholesalers) recommended reducing shipping and storage time by making only purchases on order. For peanut paste sellers, the only way to reduce contamination would be to avoid any contact with water and to put oil on the surface of paste. Indeed, most fungi involved in peanut deterioration are aerophilic. As a result, the presence of oil on the surface creates an anaerobic

environment unfavourable to fungi development.

The quality of peanut seeds is usually verified by visual, taste or touch control. However, 28.8% of traders did not apply any quality criteria. Visual inspection permits to detect presence of mouldy seeds or foreign bodies. Taste control is used to determine water content of seeds and paste quality. The water content is also estimated by touch. This expertise could be explained by the number of experience years acquired by the majority of traders. In a comparative study in Ghana, most participants reported using visual appreciation to identify poor quality peanuts [23].

Table 3.
Supply and storage conditions of peanuts in the markets according to the forms marketed in Côte d'Ivoire

Selling practices	Percentage (%) (n=66)			
	Peanuts pods (n=8)	**Peanuts seeds (n=38)**	**Peanuts paste (n=20)**	**% Total**
Method of obtaining (a)*				
Myself	0	2.6 (1)	85.0 (17)	27.3
On field	37.5 (3)	39.5 (15)	0	27.3
Wholesalers	37.5 (3)	52.6 (20)	15.0 (3)	39.4
Semi-wholesalers	37.5 (3)	13.2 (5)	0	12.1
Trackers	0	2.6 (1)	0	1.5
Storage (b)				
Yes	62.5 (5)	84.2 (32)	100 (20)	86.4
No	37.5 (3)	15.8 (6)	0	13.6
Storage container (a)*				
Bag	62.5 (5)	65.8 (25)	0	45.5
Plastic Bag	0	10.5 (4)	0	6
Aluminium bowl	12.5 (1)	21.0 (8)	35.0 (7)	24.2
Bucket with lid	0	0	85.0 (17)	25.8
Storage place (b)				
House	12.5 (1)	0	0	1.5
Market	12.5 (1)	28.9 (11)	80.0 (16)	42.4
Mill	0	0	5.0 (1)	1.5
Warehouse	0	52.6 (20)	15.0 (3)	39.4
Warehouse or truck	37.5 (3)	2.6 (1)	0	1.5
Storage time (b)**				
1-5 days	0	2.6 (1)	15.0 (3)	6.1
1-2 weeks	12.5 (1)	15.8 (6)	55.0 (11)	27.3
2-3 weeks	0	2.6 (1)	5.0 (1)	3
1-2 months	12.5 (1)	15.8 (6)	20.0 (4)	16.7
3 months	0	2.6 (1)	0	1.5
Unknown	37.5 (3)	44.7 (17)	5.0 (1)	31.8

(n) = number of individuals surveyed; (a) = strong correlation between variable and trader type (degree of significance of Khi2 <0.05 and Phi> 70%); (b) = no correlation between variable and trader type (degree of significance of chi2> 0.05); (c) = low correlation between variable and trader type (degree of significance of chi2 <0.05 and Phi <70%). *Proportions sum is greater than 100% because only one individual can have multiple answers to this question. **Proportions sum is less than 100% because this question concern only the 86.4% of traders witch conserving the unsold.

Table 4.
Loss factors, means of control and quality control of peanuts according to the marketed form in Côte d'Ivoire

Losses during selling	Percentage (%) (n=66)			
	Peanuts pods (n=8)	**Peanuts seeds (n=38)**	**Peanuts paste (n=20)**	**% Total**
Losses (b)				
0 %	12.5 (1)	39.5 (15)	80.0 (16)	48.5
2-10 %	62.5 (5)	26.3 (10)	15.0 (3)	27.3
10-50 %	25.0 (2)	7.9 (3)	5.0 (1)	9.1
Unknown	0	26.3 (10)	0	15.2
Loss factors (b)*				
Insects	25.0 (2)	8.4 (7)	0	13.6
Fungi	62.5 (5)	50.0 (19)	5.0 (1)	37.9
Humidity	12.5 (1)	5.3 (2)	0	4.5
Temperature	0	7.9 (3)	0	4.5
Long conservation	0	2.6 (1)	0	1.5
Grinding-tri	0	0	10.0 (2)	3.0
Others (pebbles, sand, transport)	12.5 (1)	10.5 (4)	0	7.6
Contamination by fungi (c)				
Yes	87.5 (7)	68.4 (26)	0	50.0
No	12.5 (1)	31.6 (12)	100 (20)	50.0
Means of control (a)				
Drying-tri	12.5 (1)	23.7 (9)	0	15.2
Sieving-tri	25.0 (2)	0	0	3.0
Reduced transport time	12.5 (1)	0	0	1.5
Purchase on order	0	2.6 (1)	0	1.5
Avoid contact with water	0	0	10.0 (2)	3.0
Cover the surface with oil	0	0	5.0 (1)	1.5
None	50.0 (4)	73.7 (28)	85.0 (17)	74.2
Quality control of peanuts (c)				
Visual-Touch (check if dry)	37.5 (3)	89.5 (34)	25.0 (5)	63.6
Visual-Taste	0	0	10.0 (2)	3.0
Taste	0	0	15.0 (3)	4.5
None	62.5 (5)	10.5 (4)	50.0 (10)	28.8

(n) = number of individuals surveyed; (a) = strong correlation between variable and trader type (degree of significance of Khi2 <0.05 and Phi> 70%); (b) = no correlation between variable and trader type (degree of significance of chi2> 0.05); (c) = low correlation between variable and trader type (degree of significance of chi2 <0.05 and Phi <70%). *Proportions sum is less than 100%, because we only counted those who experienced losses.

4. Conclusion

Peanut trade practices in Côte d'Ivoire are the same regardless of the surveyed area. Along the circuit sale, duration, location and storage containers of peanuts constitute risk factors for fungi contamination and growth. Training in good hygiene and manufacturing practices of peanut traders would be an alternative to the reduction of aflatoxin contamination, in order to ensure a better sanitary quality of peanuts in the Ivorian markets.

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