

## **Risk Factors for Spoilage of Groundnut Seeds in Shops during Marketing**

**Z. B. I. A. Boli<sup>a\*</sup>, W. H. Coulibaly<sup>a</sup>, R. Bamba<sup>a</sup>, W. M. Allouet-Boraud<sup>a</sup>,  
R. Koffi-Nevry<sup>a</sup> and K. M. Dje<sup>a</sup>**

<sup>a</sup> *Department of Food Science and Technology, Biotechnology and Food Microbiology Laboratory, University Nangui Abrogoua, 02 BP 801, Abidjan 02, Côte d'Ivoire.*

### **Authors' contributions**

*This work was carried out in collaboration among all authors. Authors ZBIAB, WHC, RB and WMAB designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors WMAB, RKN and KMD managed the analyses of the study. Author ZBIAB managed the literature searches. All authors read and approved the final manuscript.*

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### **ABSTRACT**

Post-harvest storage of oilseeds, particularly groundnut, is a real problem for farmers and traders whose stocks are subject to attacks by pests and fungal contaminants in the shops. In order to find alternative solutions to this problem, a survey was conducted in Côte d'Ivoire, specifically in the markets of the communes Abobo, Adjamé and Yopougon in city of Abidjan, Côte d'Ivoire. The objective of this work is to evaluate the main risk factors for spoilage of groundnut seeds sold during storage in the Abidjan markets. To this end, a survey was conducted among 75 groundnut seeds sellers in the three aforementioned communes of Abidjan and identified the main risk factors favorable to spoilage of groundnut seeds sold during storage. The lack of exact knowledge of the origin of the groundnut seeds sold (92 to 100%), the storage of groundnut seeds in polyethylene bags (84 to 100%), the lack of knowledge of spoilage (28 to 44%), the long periods of sale (22.2 to 86.7%), moisture (0 to 72.2%) and insect pests (5.6 to 20%) were identified as the main factors of these risk of spoilage.

\*Corresponding author: E-mail: [boliabe.sta@univ-na.ci](mailto:boliabe.sta@univ-na.ci), [bzia2011@yahoo.fr](mailto:bzia2011@yahoo.fr);

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## 1. INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an annual legume that occupies an important place in the diet because of its protein and essential fatty acid content [1]. It is a staple food for many populations and improves the quality of diets [2]. In Côte d'Ivoire, its production has been increasing steadily for several years, rising from 93.5 thousand tonnes in 2012 [3] to thousand tonnes in the 2018/2019 period [4]. Since the last two years, this production has not increased. Many losses are recorded especially during storage and the majority of these post-harvest losses are due to the effect of moulds [5]. These pathogenic fungal contaminants produce mycotoxins, which are a group of toxic substances with a range of adverse effects, including mutagenic, carcinogenic, teratogenic, etc. The most frequent targets of these mycotoxin-producing pathogenic fungi are cereals and oilseeds, particularly groundnuts. In Côte d'Ivoire, post-harvest groundnut are marketed in the city of Abidjan, which is the cultural crossroads of West Africa and is characterized by rapid urbanization. Its economic activity is reflected in the presence of a multitude of markets where commercial shops are the place of supply and unloading of several foodstuffs including groundnuts from the interior of the country. Once dumped on of market in Abidjan, the post-harvest groundnuts are stored in commercial shops before being used. Unfortunately, these groundnuts, which are widely consumed by the population in various froms, could cause a health problem due to their exposure to mould. Previous studies have revealed the presence of various pathogenic fungal genera and mycotoxins, notably aflatoxin B1 and ochratoxine A in samples of groundnut paste taken from markets in the city of Abidjan [6-7]. Post-harvest prevention of these fungal contaminants, their secondary metabolites and other pests of groundnut seeds could be a better control strategy to minimize the risks of spoilage. But to our knowledge, n study on post-harvest prevention techniques for groundnut seeds sold during storage in Côte d'Ivoire exists. This study, which aims to evaluate the main risk factor for spoilage of groundnut seeds sold during storage in the markets of Abidjan, comes at the right time to try to solve these problems faced by farmers and traders.

## 2. MATERIALS AND METHODS

### 2.1 Survey Material

In order to carry out this study, the methodological approach adopted consisted of identifying the markets, developing the data collection tool and collecting data in the form of interviews and or surveys using survey forms. Survey sheets were developed to collect information on the health risks associated with the storage and sale of groundnuts in three markets in Abidjan.

### 2.2 Presentation of the Study Area

The autonomous district of Abidjan, located in the south-east of Côte d'Ivoire, comprises five prefectures (departments), namely Abidjan-ville with its 10 communes (Abobo, Adjamé, Attécoubé, Cocody, Koumassi, Marcory, Plateau, Port-Bouët, Treichville and Yopougon), Anyama, Bingerville, Songon and Brofodoumé. The communes that were the subject of this study are Abobo, Adjamé and Yopougon (Fig. 1). These three communes were chosen because of their demographic and economic importance. The economic activity of these three communes is reflected in the presence of a multitude of markets and commercial shops that are the place where food products from the interior of the country are supplied and stored, and then to the other towns and communes of the Abidjan district.

### 2.3 Sampling

A pre-survey was carried out to identify in the field the places where groundnut seeds are sold in the three communes of the city of Abidjan. It lasted one month and allowed for the observation and design of a survey questionnaire. Based on this questionnaire, a series of surveys were conducted among groundnut sellers and in markets in three communes of Abidjan. A survey was carried out in the three municipalities under study during the period from June to July 2018, using a questionnaire. This survey concerned 75 traders, 25 per commune. The questions addressed during this survey were related to the types of peanut seeds sold, their delivery time, their storage mode and duration, the origin of these peanut seeds sold, knowledge of their spoilage, possible causes of their spoilage and spoilage solutions.

## 2.4 Sample Size

Seventy-five (75) traders were interviewed at random, with 25 traders per commune. The sample size 'n' was determined using the following formula [8-9]:

$$n = \frac{z^2 pq}{i^2}$$

z: confidence level derived from the confidence interval; CI = 90%.

p: weighted prevalence of the phenomenon; p = 50% = 0.5

q = (1-p); q = 50% = 0.5

i: allowable margin of sampling error; i = 10% = 0.1

## 3. RESULTS

### 3.1 Health Risk Factors Related to Spoilage of Groundnut Seeds during Sale in Shops

#### 3.1.1 Knowledge of the exact origin of the peanuts sold

Fig. 2 shows that regardless of the commune, the majority of traders do not know the exact origin of the groundnuts sold. This is the case in the communes of Yopougon and Abobo where 94% and 92% of traders respectively do not know the exact origin of the groundnuts sold. Again, in the commune of Adjamé, all the traders interviewed (100%) did not know the exact origin of the groundnuts sold.

#### 3.1.2 Varieties of groundnuts seeds marketed

The survey of groundnut seed traders in the shops in the three communes revealed two varieties of groundnut seeds. In general, the varieties found in these shops are small-grain and large-grain varieties. On average, 38.7% of traders sell only the small-grain variety,

compared to 24% for the large-grain variety. However, both varieties (37.33%) are sold together in the same shop (Table 1).

#### 3.1.3 Supply areas for marketed groundnuts seeds

Table 2 shows the supply areas for groundnuts sold during storage in the markets according to commune markets. Of all respondents, 47.45% said that they obtain groundnut seeds sold mainly in the northern regions, 40% in the central regions and 12.11% in eastern Côte d'Ivoire.

### 3.2 Distribution of Storage Conditions and Spoilage of Groundnut Seeds

Across the three communes surveyed, 93.33% of groundnut seeds were stored in polythene bags, compared to 6.67% in other containers. In Abobo (96%) and Yopougon (84%), most groundnut seeds are stored in polythene bags during sale, with the exception of those sold in the commune of Adjamé (100%). During the marketing of groundnuts in shops, the duration of storage generally varies from one week to more than one month. According to the traders interviewed, 28% market all the groundnuts stored for a fortnight, followed by 25.33% for more than a month and 24% for a month. However, 21.33% of traders market almost all the stored groundnuts in the first week of sale.

As for the spoilage of groundnut seeds in the shops, 64% of the traders interviewed said they had problems, compared to 36%. According to these traders, spoilage is linked to several conditions, including storage time (43.33%), moisture (37.34%), insects (13%) and other factors (2.23%). Faced with the deterioration of these groundnut seeds during storage, the majority of traders resorted to rejecting the seeds (81.1%) as a solution, while 12.66% opted for processing them into groundnut paste and 6.26% for solar drying (Table 3).

**Table 1. Varieties of groundnut seeds marketed by commune**

Commune investigated	Varieties marketed (%)		
	Small grain	Large grains	Small and large grains
Abobo	16 <sup>a</sup>	12 <sup>a</sup>	72 <sup>c</sup>
Adjamé	24 <sup>a</sup>	36 <sup>b</sup>	40 <sup>b</sup>
Yopougon	76 <sup>b</sup>	24 <sup>a</sup>	0 <sup>a</sup>
Moyennes	38,7±32,58	24±12	37,33±36,07

*In columns, values with the same letter are not significantly different at the 5% level according to the Duncan test*

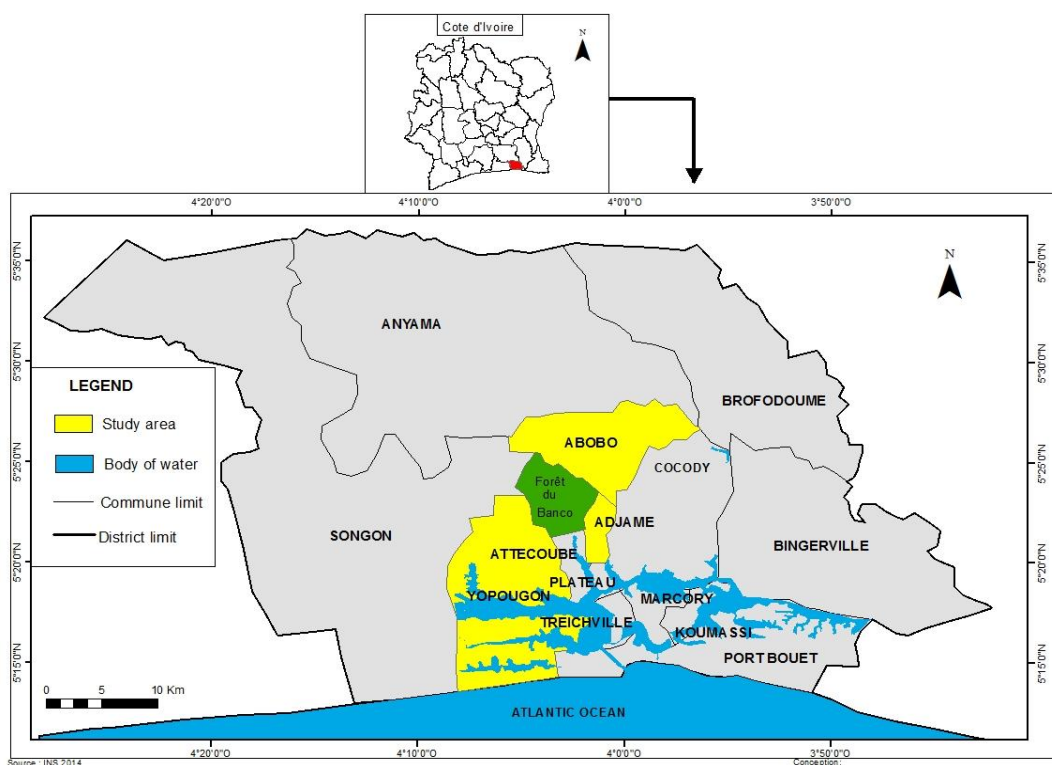


Fig. 1. Map of Abidjan district showing the study areas of the survey

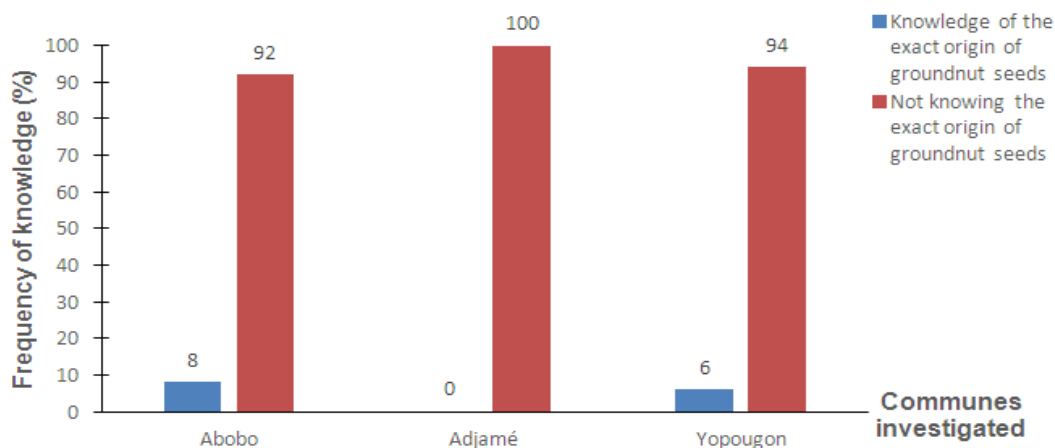


Fig. 2. Frequency of knowledge of the exact origin of groundnuts seeds

Table 2. Groundnut seeds supply areas

Commune investigated	Supply areas (%)		
	North	Central	East
Abobo	52 <sup>a</sup>	40 <sup>a</sup>	8 <sup>c</sup>
Adjamé	37,67 <sup>a</sup>	44 <sup>b</sup>	18,33 <sup>b</sup>
Yopougon	54 <sup>b</sup>	36 <sup>a</sup>	10 <sup>a</sup>
Moyenne	47,45±8,91	40±4	12,11±5,48

In columns, values with the same letter are not significantly different at the 5% level according to the Duncan test

**Table 3. Distribution of storage and spoilage conditions of peanut seeds in sales outlets**

Storage conditions	Percentage (%)			
	Abobo	Adjamé	Yopougon	Averages
Method of storage (%)				
Polythene bags	96 <sup>b</sup>	100 <sup>bc</sup>	84 <sup>a</sup>	93,33±8,33
Other means	4 <sup>b</sup>	0 <sup>a</sup>	16 <sup>a</sup>	6,67±8,33
Duration of storage				
1 Month	28 <sup>a</sup>	20 <sup>a</sup>	16 <sup>a</sup>	21,33±6,11
2 Month	28 <sup>a</sup>	28 <sup>a</sup>	28 <sup>a</sup>	28±3
3 Month	0 <sup>a</sup>	0 <sup>a</sup>	4 <sup>a</sup>	1,33±2,31
1 Month	28 <sup>a</sup>	16 <sup>a</sup>	28 <sup>a</sup>	24±6,93
+ 1 mois	16 <sup>bc</sup>	36 <sup>d</sup>	24 <sup>d</sup>	25,33±10,06
Knowledge of spoilage				
Yes	72 <sup>a</sup>	56 <sup>a</sup>	64 <sup>b</sup>	64±8
No	28 <sup>a</sup>	44 <sup>a</sup>	36 <sup>a</sup>	36±8
Cause of spoilage				
Weather	22,2 <sup>a</sup>	33,3 <sup>a</sup>	86,7 <sup>b</sup>	47,33±34,47
Moisture	72,2 <sup>b</sup>	40 <sup>b</sup>	0 <sup>a</sup>	37,34±36,17
Insects	5,6 <sup>a</sup>	20 <sup>a</sup>	13,3 <sup>a</sup>	13±7,21
Other factors	0 <sup>a</sup>	6,7 <sup>b</sup>	0 <sup>a</sup>	2,23±3,87
Solution of spoilage				
Peanut paste production	0 <sup>a</sup>	6,7 <sup>b</sup>	31,2 <sup>c</sup>	12,66±32,58
Solar drying	0 <sup>a</sup>	0 <sup>a</sup>	18,8 <sup>b</sup>	6,26±12
Peanut seeds rejection	100 <sup>b</sup>	93,3 <sup>b</sup>	50 <sup>a</sup>	81,1±36,07

*In columns, values with the same letter are not significantly different at the 5% level according to the Duncan test*

#### 4. DISCUSSION

The survey conducted among traders highlighted the traders' ignorance of the exact origin of groundnut seeds sold in the shops. This could be due to the illiteracy of most traders confirming the work of [10] who showed that 73.4% of female groundnut paste sellers in the markets of the city of Abidjan are illiterate. Indeed, in Côte d'Ivoire, illiteracy affects more than the adult population [11]. This high illiteracy is linked to difficulties in enrolment, retention and completion of primary education [12]. This study revealed that groundnut seeds are generally sourced from the North, Centre and East of Côte d'Ivoire. These findings are in agreement with the work of [10] who indicated that the origin of groundnut seeds for making groundnut paste sold in the markets of the city of Abidjan were the areas covering the North, Centre and East of Côte d'Ivoire. These results could be explained by the fact that the main groundnut production areas in Côte d'Ivoire are those covering the whole of the northern and central part of the country as indicated by the work of [13]. The majority of traders store groundnut seeds in polythene bags. These results corroborate those of [14] and [5] who reported respectively that in Ghana and Côte d'Ivoire the majority of groundnut seeds or pods are stored in polythene bags. The use of

polyethylene bags adapted for the storage of groundnut seeds could be justified by the absence of technical supervision structures that should regularly sensitise producers and traders on good post-harvest practices. Also, the low cost of the polyethylene bag compared to others such as jute bags would justify this choice. The use of polyethylene bags, which are generally poorly ventilated, is conducive to mould growth [15]. The lack of ventilation can cause a variation in temperature that can lead to condensation of water in the air. This could increase the moisture content of the peanut seeds, which is conducive to mould growth and aflatoxin synthesis.

Groundnuts are sold in storage for weeks or even months. This means that the storage period for groundnut seeds can be short or long depending on whether the selling price is suitable. The long periods of sale of groundnut seed stocks could be explained by economic reasons. Indeed, in order to cover all the capital invested or to make a profit, traders are forced to sell all the groundnut seeds available, whatever the duration. This long duration of sale of groundnut seeds could be one of the critical periods of their contamination. Indeed, according to [16], the risk of contamination of groundnuts and groundnut products increases with long marketing periods due to poor practices and

extensive handling. However, the risk of infection is high when groundnuts are stored for a long time at the trader's premises where facilities are not fully adequate.

More than the majority of traders (64%) claimed to be unaware of spoilage of peanut seeds during storage. This means that the risk of contamination could be high due to ignorance of poor storage of groundnut seeds inside the shops. According to [17], practices such as improper storage of groundnut seeds in shops contribute to their contamination with moulds and aflatoxins. Groundnut seeds are among the most susceptible food products to fungal contamination in the pre- and post-harvest stages due to their content of proteins, oils, fatty acids, carbohydrates and minerals that provide a rich medium for fungal growth [18-19]. According to traders, the main causes of spoilage of groundnuts are storage time, moisture and insects. However, most developing countries, notably Côte d'Ivoire, do not have good storage facilities in the informal sector as is the case here. This could lead to cross-contamination of groundnut seeds especially by insects which depreciate the nutritional quality of the groundnut and promote the development of moulds as already reported by [20].

The majority of traders (81.1%) faced with spoilage reject spoiled peanuts during marketing in the shops. According to them, the main way to get healthy groundnut seeds during marketing is to sort and reject the spoiled ones. However, other traders (12.66%) do not reject spoiled peanut seeds for the production of peanut paste. This practice represents a real health risk for consumers. Indeed, previous work on the storage of peanut seeds and paste during marketing in markets has revealed the presence of various pathogenic fungal genera [21-22] but also of mycotoxins, notably aflatoxin B1 [23]. Moreover, the level of exposure to aflatoxin B1 of consumers of peanut paste from peanut seeds during storage varies between 2.072 ng/kg/day and 2.193 ng/kg/day according to the work of [7]. Indeed, according to these same authors, statistical modelling of the data from this work using @RISK software leads to a population at risk of aflatoxin B1 exposure estimated at between 10.1 and 15.6% compared to the tolerable daily intake of 1 ng/kg/day. This means that there is a real cancer risk when considering the margin of exposure values for cancer which are well above the limit value of 10,000. Other work have indicated the presence of aflatoxin in

samples of peanut seeds and products including peanut butters sold in Haiti [24-25].

## 5. CONCLUSION

The results of this study showed that groundnut seeds traded during storage originate from the northern, central and eastern regions of Côte d'Ivoire. The lack of knowledge of the exact origin of the groundnut seeds sold, the storage of groundnut seeds in nylon bags, the lack of knowledge of spoilage, the long periods of sale, humidity and insects were identified as the main risk factors for spoilage of groundnut seeds sold during storage in the shops. The poor post-harvest practices of groundnut seeds sold during storage could have a health risk impact on consumers.

## 6. RECOMMENDATIONS

In order to preserve the health of consumers of food products, and particularly of marketed groundnut products, recommendations must be made at different levels.

At the level of the public authorities, the Ivorian State must:

- Carry out regular unannounced checks in foodstuff marketing outlets;
- Put in place an arsenal of regulations and oblige all actors in the sector to respect good storage practices for food products in marketing shops;
- Raise awareness among the population about the dangers of fungal contamination of groundnut seeds in order to popularise good storage practices;

At the level of traders, they should:

- Use suitable jute bags for the storage of food products
- Register with the Ministry of Trade and Handicrafts for better supervision and monitoring;
- Observe good hygiene practices during the sale of groundnuts.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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