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Surveying of the Aflatoxin Content of the Some Cereal Products in Senegal

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ABSTRACT

Cereal processing has undergone a great change with the emergence of agro-food small and medium-sized entreprise (SME) in West Africa and particularly in Senegal. But the quality of the products from these units mainly linked to aflatoxin remains the factor that limits their positioning in the international market. This study was conducted to investigation of toxic substance contents of some products in Senegal.

It is demonstrated that the most affected products are “thiere” and “thiacry” with respectively a contamination contents rate of 57% and an average content of 4.76 ppb and with a rate of 43% and an average content of 7.76 ppb. Because “thiéré” and “thiacry” are produced in the vast majority of units, from a formulation combining millet flour with that of corn which is often contaminated by aflatoxin (62.57%) at levels that are sometimes high (levels greater than 100ppb).

Ultimately, this study shows that cereal processing exposes the products to certain contamination by aflatoxin.

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Introduction

In Senegal, cereal processing sector was distinguished by the summary or precarious nature of equipments and processing degree, in short, the type of service offered (Bazabana, 1998).

During the last three decades, it has undergone a great change with the emergence, at an increased rate, of agro-food small and medium-sized entreprise (SME) in West Africa and particularly in Senegal. They are dynamic semi-industrial units, demonstrating innovation through the marketing of diversified, dried and packaged products (semolina, broken pieces, flour, precooked couscous, “araw”, infant flour, fermented cowpea flour…), located in urban centers. These long-life products offer possibilities for wide distribution. The only identified major constraints as limiting factors in the diagnostic number of this sector in Senegal are the production cost, difficulties of supplying raw materials and the positioning on the especially international market. But the products quality associated especially to aflatoxin which remains the major constraint, generally tarnishing the African agricultural products image, is relatively ignored (Shephard, 2003; Bankole and Adebanjo, 2003; Bankole and al., 2006; Wagacha and Muthomi, 2008). This may be due to the lack of information on products contamination by aflatoxins in this sector. In general, information on aflatoxin prevalence in Africa is rarely documented. Aflatoxins are major challenges to global food security systems, health, nutrition and the economy [1]. This work which combining expertise and laboratory work, aims to demonstrate the prevalence of this toxin substance (aflatoxin) of products produced in local cereal processing units.

Material and Methods

Choice of Processing Units

Cereal processing units are the target of this survey carried out between 2016 and 2017. These units are chosen according to population density and the locality economic importance in which they are located. These units are therefore located in Dakar and Touba.

The two localities unit’s choice is made at random.

In all, two types of units (semi-industrial and artisanal) are concerned. The questions integrated into the SphinxV5 software, mainly relate to management quality of raw materials and products, process, product development and the various dangers associated with each step. The data is exported to Excel for analysis.

Sampling

Five products resulting from cereals processing are targeted by this study because of their expansion and their current importance in eating habits among populations, especially urban ones. These products are: dry “araw” in bag, “thiéré” and dry “thiacry” in bag, broken millet (sanghal), instant infant flours. 400g of these products as well as those of raw material are taken from the visited units. These sampled products are from the key stages of the development process shown below (Figure 1).

Products from different productions of six most dynamic units located in Dakar which produce at least one ton per week were monitored. In all, 40 product samples including 10 samples of thiéré, 10 samples of thiacry, 10 samples of araw, 10 of broken pieces (sanghal) as well as samples of the raw material are collected.

These samples are analyzed according to the parameters: humidity level and aflatoxin dosage.

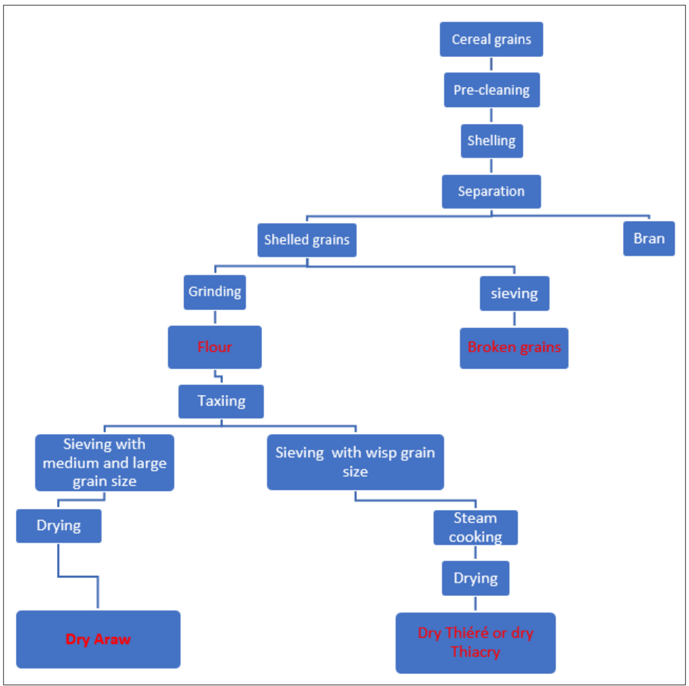


Figure 1: Different Products Manufacturing Diagram

Moisture

Samples moisture content analysis was performed by AOAC method. 18th Ed.Rev.2007 945.15 (27.4.03).

Aflatoxin Quantification

Aflatoxin quantification of samples product was done using the AFLA-V AQUA Test Procedure (0-100 ppb) below. 5g of ground corn sample is mixed with 25ml of AQUA Premix solution in a test tube. The mixture is stirred for 2 minutes and then filtered through paper filter. Using a micropipette, 0.1 ml of the filtrate is diluted in 0.1 ml of Afla-V diluent in an Eppendorf tube. This obtained solution is stirred for 20 seconds then 0.1 ml transferred into the round opening of the Afla-V strip at a rate of one drop per second. The strip is left to stand for 5 minutes (the time of reaction) on a flat, horizontal surface away from any air flow. The strip is then inserted into the virtue reader which displays directly on the screen the aflatoxin amount in sample. Results were processed by using the XLSTAT 6.1.9 software for interpretation.

Results

Cereal Processing Units

Two types of processing units are listed: artisanal units and semi-industrial units (Figure 2).

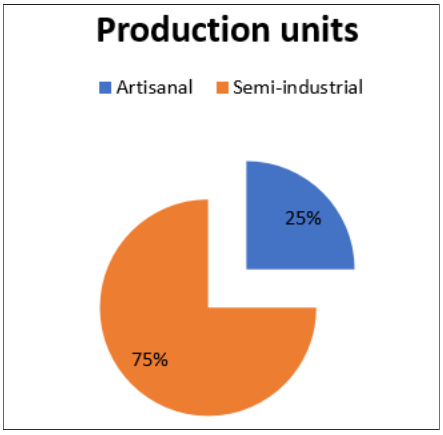


Figure 2: Different Categories of Cereal Processing Units

Equipment used in these units is traditional type and the staff use traditional methods which practically do not incorporate the HACCP method for control and prevention of risks associated with contamination. Equipment lack made that these units often resort to services to carry out some of their tasks. The average processing capacity of these units is 151.6 kg / day. Craft units represent 25% of the visited entities.

Semi-industrial units have relatively adequate equipment for cereal processing. These units are represented by small and medium-sized enterprises (SMEs) specializing in cereals processing. The staff who work there SMEs are mostly trained. However, limitations are detected in the application of HACCP rules in terms of hygiene, food safety and work management. Unlike artisanal units, all of tasks in semi-industrial units are performed on site. In addition, these units are installed in buildings that house equipment dedicated to grain processing. Generally, the units visited have four compartments: a raw material storage room, a compartment for processing activities, a finished product storage room and an administrative compartment.

The most frequently encountered equipment is the scale and the welder used by 90% and 95% of units respectively. Other essentials, with a definite impact on the product quality, such as dryers, granulators, cleaners and even destoners are the prerogative of a minority of more or less equipped units (Figure 3).

Unlike artisanal units, semi-industrial units offer semi-finished and finished products in bags and labeled. These units have an average processing capacity which is greater than 1.3 T / Day.

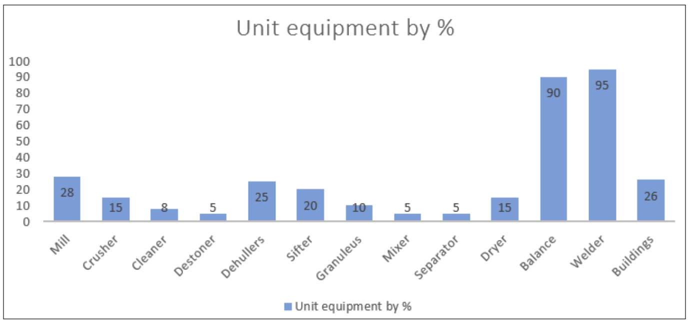


Figure 3: Percentages of Various Equipments Used by Cereal Processing Units

Processed Products Processing and Management

Raw Materials

Millet alone represents 68% and 99% of the raw material intended for processing in Touba and Dakar respectively, and in some cases is the only component of the formulation. Other cereals (maize and sorghum) are often used in low proportions mixed with millet flour. Their use often has a phonolitic purpose and makes it possible to differentiate products according to color, taste, etc. These raw materials (millet, maize and sorghum) are mainly supplied by urban wholesalers who obtain their supplies in rural areas from the collection centers for peasant production (figure 4). During its journey, the raw material is often stored in room stores and community stores. Storage materials are cloth bags and propylene bags. These materials and storage places often do not guarantee the good quality of seeds, especially due to their contamination by aflatoxin.

The investigation also revealed existence of specifications binding suppliers to the processing units. But requirements of the units stipulated in these specifications are rather physical (quantity, good appearance of seeds and absence of stones ...). They don't take into account the qualitative aspect such as presence of aflatoxin in raw material supplied.

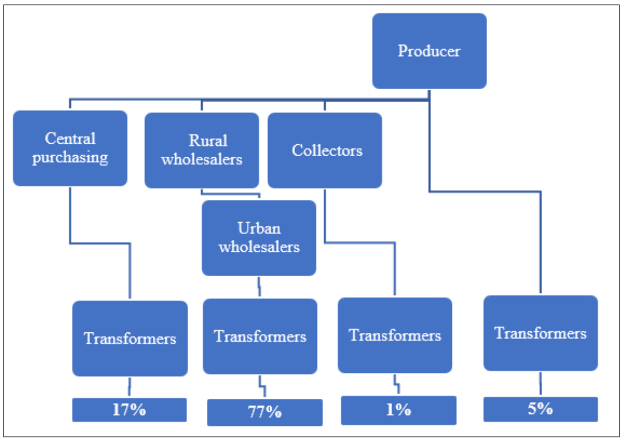


Figure 4: Raw Material Procurement by Cereal Processing Units

Products

Each product comes from a production diagram which determines its nature. These diagrams are made up of steps whose, the most important are summarized in figure 1. In addition to the raw material, the process transformation diagnosis shows that the management of certain stages such as drying and storage of products have a great influence on their production. Unlike traditional units, drying and storage of finished products before sale is carried out by semi-industrial units, in fact drying in these units is done in two ways: drying by a dryer and drying in sun by spreading out products on tables. The dryers generally used are of three types: natural dryer (sun-wind), hybrid dryer (sun-gas) and gas dryer. Dryers (hybrid and gas) are not always within the reach of all processors (Figure 3). According to users of this equipment, in addition to isolating product from its immediate environment, rapid drying lasting 4 hours an average. On the other hand, drying by spreading out on tables is an activity that presents many risks of damage in product quality. Being fully aware of these risks, units that use this type of drying employ various measures to cope. The most common protective measure is the use of transparent fabrics to cover products. In most cases, products are dried in the sun without protection on terrace (figure 5). Whatever chosen option, sun drying lasts longer than other types. It is strongly linked to environmental conditions.

Figure 5: Drying "Thiéré" in Sun

Dried products are packaged in sealed bags and stored in plastic drums or in shelves inside storage rooms. Products resulting from the various production diagrams and packaged in bags are labeled with an expiration date which varies from 1 to 2 years. These various technological innovations applied to finished and semi-finished products thus facilitate their acceptance in urban household food ration. Their markets distribution is done through various strategies (figure 6). But the most widely used distribution method is direct sales. These distribution strategies make products accessible to the different social layers of population (average and well-off).

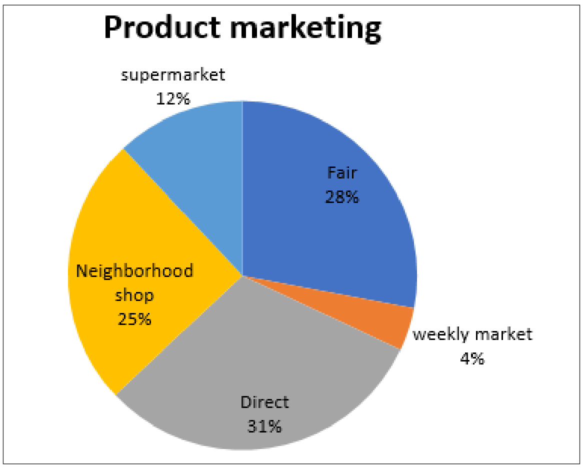


Figure 6: Cereal Products Distribution in Senegal Urban Markets

Unlike their export, cereal products quality associated with the presence of aflatoxin hardly hinders their distribution in urban markets. According to the survey results, quantification of aflatoxin in these products is not systematically carried out with each production. This is generally only carried out in the case of products intended for export.

Raw Material and Products Quality

Moisture Rate

The average moisture content of products is generally above 8% (Figure 7). This demonstrates the ineffectiveness of the drying techniques generally used by cereal processing units. The highest water contents are noted in products which are drying in the sun (between 10% and 13%). On the other hand, drying using dryers is often the source of products with a suitable humidity level varying between 7 and 9%. The high humidity level of products makes difficult their long-term storage. It allows the growth of microorganisms such as molds and aflatoxins production. In addition, it accelerates the early deterioration of the products taste.

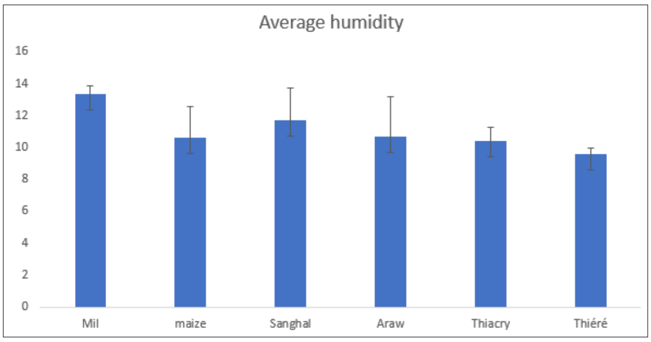


Figure 7: Products and Raw Materials Average Moisture Level

Aflatoxin Contamination

Aflatoxin quantification results given in the below table show that "thiéré" and "thiacry" are the most frequently contaminated products with respectively 57.14 and 42.85% of the samples compared to "araw" and "sanghal", which only 28.57% aflatoxin contains. The highest aflatoxin contents have been recorded in these products (thiacry and thiéré) (maximum content: 67.65 ppb for thiacry and 47.06 ppb for thiéré). On the other hand, very low Aflatoxin concentrations were noted in "sanghal" and "araw" with mean values of 1.50 ppb and 1.60 ppb respectively.

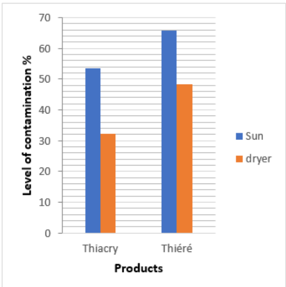
Table 1: Contamination Rate and Amount Products Aflatoxin (AFLA-V AQUA test procedure (0-100 ppb))

Products	Mil	Sankhal	Araw	Thiacry	Thiéré	Maize
Afla Cont. rate (%)	22.56	28.57	28.57	42.85	57.14	62.57
Min-max Val. (ppb)	1.6 - 1,54	1.23 – 5.4	1.3 – 3.42	1.79 – 67.65	0.26 – 47.06	7.56 – 117.20
Average afla (ppb)	1.59	0.57	0.32	7.76	4.76	22.50

Cont= contamination ; Val= value ; afla= aflatoxin

It emerges from these results that the contamination level differs according to the nature of product. This justifies the impact of raw material and the transformation process on product contamination by aflatoxins.

Sun-dried thiéré and thiacry have significantly higher contamination rates than products from dryers. Likewise, on average aflatoxin concentration is proportionally higher in sun-dried products (Figure 8). The dryer allows units to produce thiacry and thiéré with a relatively low contamination rate (32% and 48% respectively) with respective average contents of 7.10 ppb and 9.35 ppb. Contrariwise, more than half of the samples of thiéré and thiacry are contaminated with respective mean amount of 4.76 ppb and 7.76 ppb (figure 9). Equipping cereal processing units with a dryer can therefore be an effective barrier against strong accumulations of aflatoxin in products.



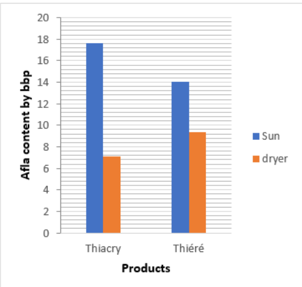


Figure 8: Contamination level **Figure 9:** Aflatoxin level

Discussion

The absence of regulations in Senegal limiting aflatoxins presence in cereal products sold in urban markets largely justifies the behavior of processing actors. Overall, our investigation results demonstrated absence of legislation to deal with possible aflatoxin contamination of products. All precautions taken by those involved in processing are aimed above all to limiting physical contamination. Thus, actions to limit influence of essential parameters of aflatoxin accumulation in products are often disregarded.

Our results show that average humidity of products is higher than the required standard for good product conservation, which is 8%. In fact, this inadequate humidity which is characteristic of produced products is a key factor which strongly argues for the presence of aflatoxin in them. This correlation between humidity accompanied by a high product water activity and their aflatoxin content is demonstrated by many studies including those of [2-4]. These humidity levels listed in our study, varying on average between 10% and 12% depending on the product, justify, in addition to the inefficiency of the drying process in aflatoxin content in the latter.

According to the obtained results (table), millet is not frequently contaminated with aflatoxin. Their contents are low (average content of 3.19 ppb). Depending on the processors, the drying time of "araw" and "sankhal" is shorter compared to other products. This limits their exposure to contamination by molds. These two factors combined mean that these two products are more or less spared from aflatoxin contamination. Conversely, the dehydration of "thiéré" or even of "thiacry" being longer in duration can be at risk. Indeed, the production process involves stages sensitive to contamination (crumbling or drying under the sun). In addition, "thiéré" and "thiacry" are produced in the vast majority of units, from a formulation combining millet flour with that of corn. The latter is often contaminated by aflatoxin (62.57%) at levels that are sometimes high (levels greater than 100ppb). These parameters thus exposed, to which are added the water content of the products, the conditions and duration of storage, in most cases favor concentration of aflatoxin in "thiéré" and "thiacry".

The issue of aflatoxin concentration in these products was already mentioned by the producers during the survey. Indeed, because of aflatoxin, large quantities of products from some of them were turned back to the port, causing enormous economic losses. Thus, the results of this study show that the effective presence at high levels of aflatoxin in products from cereal processing units is strongly correlated with raw material quality and especially with the transformation process.

The most affected products are "thiere" and "thiacry" with respectively a contamination contents rate of 57% and an average content of 4.76 ppb and with a rate of 43% and an average content of 7.76 ppb. Regarding their, our results characterizing presence of aflatoxin are clearly above those found by on samples of this product sold on the Senegalese market (contamination rate 14% with an average content of 1.7 ppb) [5]. Nevertheless, the two studies show similar ranges of contamination. Compared to that of, of which the basic cereal is only millet, thiéré in our case, is most often made from the combination of millet flour and that of corn very frequently contaminated with high content. Also our study revealed that the Sun-dried products have a contamination rate that is well above those of products from dryers. This allowed us to highlight in our study the very significant impact of drying processes on the quality of finished products. Impact has been noted in numerous studies such as that of or that of [6, 7]. These studies have shown that the mechanized drying of products (driers) can be a barrier that limits the accumulation of aflatoxin in products.

Conclusion

Cereal processing in Senegal is generally carried out in precarious conditions despite the efforts of the public authorities to promote this sector. Indeed, the survey results revealed that the level of cereal processing units equipment is low. Equipment like dryers that have a clear impact on product quality remains the prerogative of a minority of more upscale units. As a result, drying products in the sun is the most common technique. The humidity test has shown the cause of almost widespread use of this technique. The average water content of products is slightly high compared to that recommended for good storage. Also, in addition to the raw material quality, the study has shown that this technique of drying products greatly influences their contamination by aflatoxin. The highest contamination rates and aflatoxin contents were specifically noted in two products: “Thiacry” and “Thiéré”. In addition, the aflatoxin content of these products resulting from drying under the sun is greater than that of products dried in driers. Ultimately, this study shows that cereal processing, with the conditions under which it is carried out, exposes the products to certain contamination by aflatoxin.

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