Diversity of Micro, Small and Medium Cereal Milling Enterprises in Nairobi County, Kenya and Levels of Aflatoxins in Their Milled Products

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Abstract In Kenya, aflatoxicosis is a major public health problem and several outbreaks have occurred in the past due to the consumption of contaminated maize and maize products. Even when there are no reported cases of illness or deaths, it is believed that the consumer is constantly exposed to sub-lethal doses of the toxin. The maize products consumed include meals and flours either pure or in admixture with other cereal flours. The mixes are manufactured by small scale millers found widespread in the county who do very little quality control on their products. This study was designed to establish the nature, diversity and usage of milled flour products from Micro, Small and Medium Enterprises (MSMEs) in Nairobi County and also assess levels of aflatoxin contamination in the products. Questionnaires were administered to 107 MSMEs and a total of 32 flour samples of maize, sorghum, finger millet and peanut were collected for analysis of aflatoxin. Results showed that of the 168 MSMEs registered by the Nairobi City Council in the year 2013, most were Micro enterprises. The total aflatoxin levels in the flour samples ranged from 2,190.30 – < 1 µg kg⁻¹. Of each of the 8 flour samples of maize, sorghum and peanut tested, 3, 6 and 5 respectively had aflatoxins levels above the national tolerable level of total aflatoxin in human food of 10 µg kg⁻¹ (Kenya Bureau of Standards 2013). Peanut flour had the highest mean total aflatoxin level contamination at 304.51 µg kg⁻¹. The mean total aflatoxin levels in maize, sorghum and millet flours were 59.73 µg kg⁻¹, 39.21 µg kg⁻¹ and 34.80 µg kg⁻¹ respectively. The study established that there is a great diversity of flours and their mixes supplied by MSMEs in Nairobi. The individual pure flours were however contaminated with aflatoxins above the tolerable limits. The flour mixes would also have similarly high levels of aflatoxin.

Keywords: aflatoxins, cereals, survey, exposure, immunoassays


1. Introduction

Micro-, Small- and Medium-Enterprises (MSMEs) play a crucial role in driving economic growth in both developing and developed countries [2]. In Kenya, MSMEs play a key role in the new economic development strategy “Kenya vision 2030” by providing 80% of employment and contributing 40% to GDP [9]. The Micro- and Small-enterprise (MSE) Act passed in 2012 by the National Government, consolidated the regulatory and institutional policy framework surrounding these enterprises [10]. Categorization or definition of MSEs in the Act is based on number of employees and annual turnover. A micro enterprise should have 1-9 employees and annual turnover not exceeding KES 500,000; while a small enterprise should have 10-50 employees and annual turnover of between KES 500,000 to 5 million (1 USD = KES 90).

However, the 2012 MSEs Act does not provide criteria for defining a medium enterprise. According to Africa Centre for Open Governance [1], a medium enterprise should have 50-99 employees.
better nutrition. These composite flours are used to prepare gruel/porridge for both children and adults. Coupled with the diversity of flour products, customer preferences and lower prices these products have a competitive price edge over the commercially milled products.

Unlike in the large commercial millers where strict quality control is practiced, MSMEs millers and flour traders only carry out simple quality checks such as cleaning and dusting on their raw materials [5]. No chemical quality control tests like aflatoxin testing are done on the raw material received. Therefore the safety of their products in terms of aflatoxin contamination is difficult to guarantee especially in Kenya where aflatoxin poisoning has been reported almost every year. According to Muyanga et al. [8], adult consumption of ugali from maize meal purchased from the informal millers is popular, especially among the urban poor. This would constitute a significant source of aflatoxin exposure to individuals. With regard to children, the weaning foods of choice in Kenya consist of porridge prepared from these flours. Therefore, the transition from breast milk to highly contaminated weaning foods is of public health concern. According to Wild [13], “the nature of the weaning food, the relative quantities as compared with breast milk, and the duration of weaning before introduction of family foods have been reported to impact on the amount of aflatoxin exposure at this potentially critical period in life”. Kenya has high stunting rates of 35% and malnutrition global rate (Acute Malnutrition [GAM]) stands at 7% [7]. In order to be effective, interventions aimed at improving the nutritional status of children must therefore address the issue of aflatoxin contamination of foods.

The levels of aflatoxin in porridge flours supplied by MSMEs in Nairobi County and their impact on children growth have nevertheless not been assessed. The objectives of this study were twofold: to determine the diversity of flour milling and retailing MSMEs and milled products supplied by the MSMEs in Nairobi County, Kenya, and, to assess the levels of aflatoxins in milled flour products handled and supplied by these enterprises in the said County.

2. Materials and Methods

2.1. Study Design and Sampling Framework

The study was cross-sectional survey carried out among MSME flour millers and retailers in Nairobi County, Kenya. According to the Nairobi County, Department of Public Health food handling licensing records, there were 168 registered MSME flour millers in Nairobi County in 2013. Sample size estimation for descriptive statistics, with the correction for finite population, was used to calculated the sample size [4]. Therefore a sample size of 107 was calculated at confidence level of 95% and margin of error of 5% (P = 0.05). However, there were no records on registered MSME retailers who sell flour products.

Convenient sampling was done along established streets or roads in Nairobi County. A semi-structured pretested questionnaire was administered to 107 MSME flour millers and suppliers within Nairobi County. The enterprises interviewed were those that mill flour and directly supply the milled flour products to the public, and those who purchase flours from the millers and sell to consumers. The questionnaire elicited questions on the nature and diversity of milled products supplied by MSMEs, the average daily turnover of the flour products, their usage and whether quality control tests are carried out on the cereal grains before milling. Descriptive analysis of survey data, using Statistical Package for Social Sciences (SPSS 16.0), was done to provide information about the variables followed by inferential analysis.

2.2. Flour Sample Collection

A total of 32 flour samples of maize, sorghum, finger millet and peanut flour products (8 samples of each type) that are prone to aflatoxin contamination and commonly used to make composite flour porridge for children and adults were collected from randomly selected MSMEs that had been previously interviewed (Figure 1). The samples were then analysed for aflatoxins.
To ensure collection of representative samples, sampling, using a spike, was done from the top, mid and bottom of the bag/container and sampled portions were mixed to make a combined sample. The combined flour samples were packed in brown kraft paper bags, sealed with masking tape and stored in a cool, dark and dry place to preserve and maintain the flours in the same state as when collected.

2.3. Analysis of Aflatoxin in Flour Samples

The flour samples were analysed for total aflatoxins using the rapid screening aflatoxin Enzyme Linked Immunosorbent Assay (ELISA) test kit (Cat. No. 941AFL01M – 96 Helica Biosystems®, USA). All reagents were maintained at room temperature before use. Extraction of aflatoxin from the flour samples was done using 70% methanol, at a ratio of 1:5 sample to extraction solvent. Six aflatoxin standards of concentrations: 0.0 µg kg⁻¹, 1.0 µg kg⁻¹, 2.5 µg kg⁻¹, 5.0 µg kg⁻¹, 10.0 µg kg⁻¹ and 20.0 µg kg⁻¹ were used to prepare standard curve.

Then 200µl of the conjugate was dispensed into each dilution well. Using a new pipette tip, 100µl of each standard and sample were added to appropriate labelled dilution wells containing conjugate. Mixing was done by priming the pipettor at least 3 times. Using a new pipette tip for each, 100µl of contents from each dilution well was transferred to a corresponding antibody coated microtiter well. This was followed by incubation of the microtiter wells at room temperature (23-25°C) for 15 minutes. The contents were then decanted into a basin. The microwells were washed by filling each with distilled water and then decanting the water into a basin. A total of 5 washings were done. Residual water from these microwells was removed by tapping the wells face down on a layer of absorbent paper.

Then 100µl of substrate reagent was added to each microwell followed by incubation at room temperature (23-25°C) for 5 minutes to allow reaction with the enzyme portion of the conjugate. The wells were covered to avoid direct light. After incubation, 100µl of the stop solution was added to each microwell in the same sequence and at the same pace as the substrate was added. Finally, the Optical Density (OD) of each microwell was read with a microtiter plate reader using a 450nm filter. The analysis of data on aflatoxin levels was done by Kruskal Wallis statistical test.

3. Results

3.1. Nature of Micro, Small and Medium Enterprises in Nairobi County

As shown in Figure 2, out of 107 respondents, 93.6% were micro enterprises having less than 10 employees, 5.5% were small enterprises having 10 to 50 employees and 0.9% were medium enterprises having 50 to 99 employees.

![Figure 2. Proportion of MSME type in Nairobi County](image1)

![Figure 3. Average daily sales in bags (90kgs) by MSMEs](image2)
Figure 4. Type of core business of MSMEs and market share of each

Fifty four percent (54%) of all the MSMEs sell < 1 bag of flour per day while only 6% sell ≥ 10 bags of flour per day. (Figure 3)

The core businesses and proportion of market share of all the interviewed MSMEs are shown in Figure 4. Majority (56%) of the MSMEs mill and sell, 23% buy and sell milled flour products while 18% of the MSMEs take grains to millers to mill on contract then sell the milled flour products through either wholesale or retail outlets. Less than 2% of MSMEs do a combination of these activities. Of the 56% that sell own milled products, only 12% grow cereals for milling, while the rest (88%) buy cereal grains from farm producers or intermediaries (wholesalers) located either in Nyamakima, Dagoretti and Kangemi markets within Nairobi County or in other parts of the country.

3.2. Nature and Diversity of Milled Products

A diversity of more than 20 different milled products, ranging from cereal to legume flours are milled and sold by the MSMEs in Nairobi County. The milled products identified in the market were: - maize meal, maize flour, sorghum, finger millet, pearl millet, foxtail millet, cassava, wheat, groundnuts, silver cyprinid (omena), stinging nettle, amaranth seeds, soya beans, other beans (black beans, kidney beans, rosecoco beans and assorted varieties of kidney beans), green grams, pigeon peas, cow peas and cow pea leaves, pumpkin seeds, flax seeds, oats, rye, rice and sim sim.

As shown in Table 1, micro enterprises supply over 86% of a diversity of milled products in the Nairobi County market while medium enterprises supply only one type of milled product (maize flour).
Table 1. Percentage of milled products supplied by each enterprise.

<table>
<thead>
<tr>
<th>Milled Product</th>
<th>Type of Enterprise Supplying Milled Products</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Micro Enterprise</td>
</tr>
<tr>
<td>Maize meal</td>
<td>95</td>
</tr>
<tr>
<td>Maize flour</td>
<td>90</td>
</tr>
<tr>
<td>Sorghum flour</td>
<td>94</td>
</tr>
<tr>
<td>Millet flour</td>
<td>93</td>
</tr>
<tr>
<td>Cassava flour</td>
<td>93</td>
</tr>
<tr>
<td>Wheat flour</td>
<td>86</td>
</tr>
<tr>
<td>Protein rich flours (p/nuts, soya, omena)</td>
<td>95</td>
</tr>
<tr>
<td>Stinging nettle flour</td>
<td>93</td>
</tr>
<tr>
<td>Amaranth seed flour</td>
<td>95</td>
</tr>
<tr>
<td>Green gram and pigeon/cow peas flour</td>
<td>90</td>
</tr>
<tr>
<td>Beans flour</td>
<td>100</td>
</tr>
</tbody>
</table>

Figure 5 shows the most popular pure flour products sold by MSMEs. Being the staple food of Kenyans, maize meal (88%) was the most commonly supplied product followed by finger millet flour (71%) and sorghum flour (66%). Pearl millet, cassava and protein dense flours such as peanut, soya bean and silver cyprinid flours are the least sold flours.

Sixty two percent (62%) of the MSMEs sell composite flours while the rest do not. The composite flours are made from varied mix ingredients but sorghum, finger millet and maize flours are common ingredients. Below is a listing of some common flour mixes.

1) Maize+sorghum+finger millet
2) Maize+sorghum+finger millet+peanuts
3) Maize+sorghum+finger millet+peanuts+silver cyprinid
4) Maize+sorghum+peanuts+amaranth seeds
5) Sorghum+finger millet+amaranth seeds
6) Sorghum+finger millet+peanuts/silver cyprinid
7) Sorghum+finger millet+cassava+soya beans
8) Maize meal+soya beans+amaranth
9) Maize + sorghum + pearl millet + finger millet + peanuts/soya beans
10) Maize meal+maize flour+cassava
11) Maize+sorghum+finger millet+cassava
12) Maize+finger millet+rice
13) Maize+sorghum+peanuts+amaranth seeds+rice
14) Pearl millet+finger millet+peanuts+silver cyprinid +stinging nettle+wheat
15) Peanuts/silver cyprinid+soy beans+cassava+wheat.

There is no standardization in terms of ingredient proportion of the composite flour mixes across the industry. However, maize, sorghum, finger millet and peanut flour ingredients are commonly found in the composite flour mixes used to make porridge for both children and adults. The proportion of these ingredients varies from enterprise to enterprise but the cereals tend to be mixed in equal higher ratios while the protein rich flours like peanuts, beans and silver cyprinid are added in smaller quantities. The MSMEs refer to these composites either as "Nutritious Mix", "Uji Mix", "Baby Mix" etc. Citric acid crystals are added to composite flours sold by some MSMEs. This type of flours simulate fermented porridge which is popular in Kenya. MSMEs who supply high protein composite mixes indicated awareness of such high protein ingredients, especially in flours for children and other vulnerable persons. Fifty four (54%) of MSMEs indicated that customers consult them with regard to flours for specific groups of people, for example flours for normal (healthy) children and adults, children with rickets, malnourished children, diabetic adults or adults with arthritis. The MSMEs usually make special composite flours for each of these conditions. Certain flour ingredients are commonly recommended to prepare composite flour mixes that meet the nutritional needs of the ailing person.

3.3. Quality Control Procedures Employed by the Enterprises

The quality control tests carried out by MSMEs are very simple. About 64% of the MSMEs carried out simple removal of impurities through sieving, sorting or winnowing, 30% carried out sensorial observation, touching or even biting or chewing of grains to check level of dryness, maturity or presence of pesticide residues. Six (6) percent do rodent control in the environment. The MSMEs only take high quality grains from suppliers. No aflatoxin analyses were performed on the cereal grains or flours.

3.4. Levels of Aflatoxin and the Factors Contributing to Aflatoxin Contamination

The aflatoxin levels in the flour products are as shown in Table 2. Peanut flour had the highest mean aflatoxin level at 304.5 µg kg⁻¹. The mean aflatoxin level in maize flour, sorghum and millet flours was 59.7, 39.2 and 34.8 µg kg⁻¹, respectively. However, Kruskal Wallis test showed that there was no significant difference (P>0.05) in aflatoxin levels between the means of the four flour products from different MSMEs. However, the ranges are quite wide. Out of 8 flours sampled from the 8 different MSMEs, 3 (37.5%) of maize flour, 6 (75%) of sorghum, 5 (62.5%) of peanuts and only 1(12.5%) of finger millet flours had higher levels of aflatoxin than the maximum allowable level in human food of 10 µg kg⁻¹ [6]. These figures indicate high levels of aflatoxin contamination from these flour ingredients used in formulating the composite flour mixes.
Eighty seven percent (87%) of the samples with aflatoxin above the maximum allowable level of 10 µg kg\(^{-1}\) were from micro enterprises while 13% were from small enterprises. The Fisher’s Exact values of diverse factors that would influence aflatoxin levels in the flour products from the different MSME miller cross tabbed against the above aflatoxin levels are shown in Table 3. None of the quality control and storage condition variables significantly influenced the variation in levels of aflatoxin contamination in the flours. The aflatoxin levels were categorized as Low (0-10 µg kg\(^{-1}\)), Medium (11-50 µg kg\(^{-1}\)) and High (>50µg kg\(^{-1}\)).

### Table 2. Levels of aflatoxin (µg kg\(^{-1}\)) in pure flour samples collected from MSMEs.

<table>
<thead>
<tr>
<th>Flour Samples collected from different MSMEs</th>
<th>Levels of Aflatoxin (µg kg(^{-1})) in Flour Product Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maize Flour</td>
</tr>
<tr>
<td>MSME 1</td>
<td>341.9</td>
</tr>
<tr>
<td>MSME 2</td>
<td>97.5</td>
</tr>
<tr>
<td>MSME 3</td>
<td>30.7*</td>
</tr>
<tr>
<td>MSME 4</td>
<td>3.5</td>
</tr>
<tr>
<td>MSME 5</td>
<td>3.1</td>
</tr>
<tr>
<td>MSME 6</td>
<td>1.2</td>
</tr>
<tr>
<td>MSME 7</td>
<td>&lt;1</td>
</tr>
<tr>
<td>MSME 8</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

The levels with an asterisk were detected in flour samples from small enterprises. All the other aflatoxin levels were detected in samples from micro enterprises.

### Table 3. Cross tabulation of various quality control and storage variables against aflatoxin levels in flours from MSMEs.

<table>
<thead>
<tr>
<th>Independent Variable: Aflatoxin levels</th>
<th>Quality Control &amp; Storage variables</th>
<th>Values in each variable</th>
<th>Fisher’s Exact Value (P&gt;0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Type of core business</td>
<td></td>
<td>0.833</td>
</tr>
<tr>
<td></td>
<td>Type of Quality Control (QC) tests done on raw material</td>
<td></td>
<td>0.670</td>
</tr>
<tr>
<td></td>
<td>Cleaning of raw material</td>
<td></td>
<td>0.301</td>
</tr>
<tr>
<td></td>
<td>Drying of raw material</td>
<td></td>
<td>0.107</td>
</tr>
<tr>
<td></td>
<td>Packaging material of raw material</td>
<td></td>
<td>0.432</td>
</tr>
<tr>
<td></td>
<td>Awareness of raw material storage conditions prior to purchase</td>
<td></td>
<td>0.274</td>
</tr>
<tr>
<td></td>
<td>Storage conditions monitored where raw materials are stored</td>
<td></td>
<td>0.083</td>
</tr>
<tr>
<td></td>
<td>Length of storage of raw material</td>
<td></td>
<td>0.788</td>
</tr>
<tr>
<td></td>
<td>Cleaning of storage room</td>
<td></td>
<td>0.437</td>
</tr>
<tr>
<td></td>
<td>Packaging material of milled flour product</td>
<td></td>
<td>0.449</td>
</tr>
<tr>
<td></td>
<td>Storage conditions monitored where milled flour product is stored</td>
<td></td>
<td>0.504</td>
</tr>
<tr>
<td></td>
<td>Length of storage of milled flour product</td>
<td></td>
<td>0.715</td>
</tr>
</tbody>
</table>
4. Discussion

4.1. Nature and Diversity of Micro, Small and Medium Enterprises that Supply Flour Products

Majority (93.6%) of the MSMEs interviewed were micro enterprises. This agrees with a World Bank report which cites a survey of MSMEs in Kenya done in 1999 which reported that above 90% of all general enterprises were microenterprises [12]. Though these micro enterprises have less than 10 employees and have an average daily turnover of less than 90 kg flour, they have successfully infiltrated the flour market, especially within the densely populated lower income Eastland areas of Nairobi County. These findings agree with Muyanga et al. [8] who reported that the consumption of cereal products from informal millers in Nairobi County is highest among the urban poor. Nevertheless, Kang’ethe [5] observed that there is an increased demand for these products in Kenya owing to the growing consumer awareness of their health benefits. Thus, these flour millers are also found in higher income areas of the County such as Langata and Westlands.

Since majority (56%) millers buy the cereal grains from either maize producers or middlemen they are not capable of controlling aflatoxin contamination in the flour as the raw maize is contaminated at pre- or post- harvest stage. The flour suppliers are quite a diversity consisting of millers and dealers with little knowledge and/or control over the quality and storage of both the raw materials and the flour products. Their role in quality control would therefore be to maintain quality and food safety of products as bought from the maize producers and millers.

4.2. Diversity of Flour Products

The diversity of flour products sold by MSMEs is wide with over twenty (20) different products ranging from cereals and legumes to nuts and fish. This diversity parallels the diversity of MSMEs. Over 90% of the enterprises supplying the various composite flour mixes are micro enterprises while 10% or less are small enterprises. Medium enterprises mostly specialize in supply of only one product, maize flour.

This diversity results from mixing of different types of flour by over 60% of the enterprises. A study by Kang’ethe [5] also reports that these enterprises undertake value addition through blending of a variety of different flours resulting in flour mixes that are described as nutritious. Most of these composite flours are consumed as porridge by both children and adults with the aim of maintaining or improving health. The survey revealed that there are no standardized ratio for formulating or blending the flours to make composite flour even within the same enterprise. It is left to the discretion of either buyer or seller or both upon consultation. The common cereal flours (maize, sorghum and finger millet) tend to be mixed in almost same ratio by individual enterprises. The number of ingredients in the composite mix varies considerably and could reach as high as eight.

4.3. Aflatoxin Levels in Flour Samples

Aflatoxin levels detected in the 32 samples agreed with Freitas and Brigido [3] report that commodities with the highest risk of aflatoxin contamination are maize and peanuts. In this study, peanuts and maize flours were found to have the highest aflatoxin levels of 2,190 µg kg\(^{-1}\) and 342. µg kg\(^{-1}\), respectively, which are far above the Kenya Bureau of Standards maximum allowable limit of 10µg kg\(^{-1}\). Most of the contaminated samples with aflatoxin levels above maximum allowable limit of 10 µg kg\(^{-1}\) were from micro enterprises. The implications of these results is critical because micro enterprises sell their products through the informal market, which are out of control of the government regulatory body and therefore control of exposure to aflatoxin from these sources is difficult. Success of such regulatory control will depend on rigorous education of the MSMEs in quality control of the sources of the raw material, which in most cases is from small scale farmers.

4.4. Factors Contributing to Aflatoxin Contamination of Flours

The Fisher’s Exact value (P >0.05) of diverse factors that could have an influence on the degree of aflatoxin contamination showed that none of the factors was significant. The reason for this could be that most of these MSMEs buy already contaminated cereal or flour products and therefore any quality control measure they employ would not make a significant difference in the level of aflatoxin contamination. These MSMEs do not have control over prior harvesting and handling practices that can reduce contamination of products and therefore no action at their level can significantly affect aflatoxin levels.

5. Conclusions

MSMEs in Nairobi County are of diverse nature and most are micro enterprises that supply a diversity of flour products ranging from pure cereal and legume flours to composite mixes. There are over 20 different flour products not standardized with regard to ingredient proportions. These are often sold as composite flours to prepare porridge for both sick and healthy children and adults.

These flour products are contaminated with aflatoxins with peanut and maize flours having the highest contamination levels. The enterprises receive already contaminated products from farm producers and middlemen and the quality control measures currently carried out by the MSMEs are inadequate and not targeted to aflatoxin levels. These products are generally sold in the informal market and therefore government regulations do not directly apply to them.

There is urgent need for policy development by the National Government to ensure quality and safety of flour supplied by MSMEs. Education of these MSMEs on the health hazards of high levels of aflatoxin contamination in their products is recommended. Education also on quality assurance protocols such as identification of clean sources of raw materials, checking for sources of contamination and proper storage and packaging of products will...
significantly contribute to the reduction of aflatoxin contamination.

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References