AFLATOXIN IN MARKET PEANUTS AND PRE-TREATMENTS PRIOR TO ROASTING TO REDUCE LEVELS

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DEDICATION

This dissertation is dedicated to my guardians, Lucy and Gabriel Wairegi who played a big part in bringing me up and teaching me the advantages of working hard and ensuring that I become self-responsible. I also dedicate it to my closest friend Harrison Mwangi, to my siblings Joseph King'ori and Gabriel Wairegi for their motivation and teaching me on the virtue of not giving up.

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LIST OF ACRONYMS

KEBS	Kenya Bureau of Standards
FAOSTAT	Food and Agricultural Organization Statistical Databases
DNA	Deoxy-nucleic acid
FDA	Food and Drugs Administration
AOAC	Association of the Official Analytical Chemists
HPLC	High Performance Liquid Chromatography
ELISA	Enzyme Linked Immunosorbent Assay
PPB	Parts per Billion
UV	Ultra violet

OPERATIONAL DEFINITIONS

Roasting

Cooking in an oven or over an open air

Aflatoxin

Poisonous carcinogens and mutagens that are produced by Aspergillus

Post-harvest practices

Processes done immediately after harvesting which include cooling, cleaning, sorting, packaging, transport and storage.

Aflatoxicosis

Poisoning that results from ingesting Aflatoxin.

Tolerance Levels

The set upper limit of how something can be tolerated.

Nixtamalization

Preparation of grains where they are soaked and cooked in alkaline solution then hulled.

Mycotoxins

A toxic secondary metabolite produced by organisms of the fungus kingdom

Socio-demographic

Of, pertaining to or characterized by a combination of sociological and demographic characteristics

Socio-economic

Of or pertaining to a combination of economic factors which include factors such as income, education, employment, which can significantly affect how well we live.

Conc.

Concentration

ABSTRACT

In the recent past aflatoxin in peanuts and the products has been a subject of controversy in Kenya. Brands of locally manufactured peanut butter were withdrawn from the market shelves on account of them containing levels of aflatoxin higher than the national tolerance for total aflatoxin of 10ppb. It has been established that Kenyan market peanuts contain high levels of aflatoxin. Roasting, the step expected to reduce aflatoxin levels during manufacture of peanut butter and products is reported not to be effective in lowering the toxin. This study was therefore designed to apply specific pre-treatments prior to roasting to reduce the aflatoxin levels to below the tolerance, to ensure similar levels in the roasted peanuts and products. The treatments included soaking in cold and warm water, warm solution of calcium hydroxide of concentrations 0.01 – 0.04%, and UV irradiation. One-kilogram samples of peanuts were collected from 20 vendors in Nyamakima, the main Cereal Market in Nairobi. By random sampling, 40 peanut vendors were selected from exhaustively. Using a semi-structured questionnaire, the vendors were interviewed for their socio-demographic, socio-economic and the peanut vending characteristics. The peanut samples were brought to the laboratory of the Kenya Bureau of Standards (KEBS) and analysed for moisture and aflatoxin. Then 100g of each sample were weighed in duplicates and each batch soaked in water, warm water and warm calcium hydroxide for periods of up to five minutes at one minute intervals, with light agitation. Each time the peanuts were drained of water then dried in an air oven at 80^{o}C for 10 minutes to remove the surface water. A similar batch of peanuts in duplicates was spread on plastic paper as monolayer and irradiated with UV for up to 2 hours. Moisture was determined as percent by drying in a thermostatic air-oven at 105^{o}C after grinding to pass through 4mm sieve to constant weight.

Aflatoxin was analysed using ELISA (Helica Technology) on the ground samples and expressed as total aflatoxin in ppb. The results were subjected to statistical analysis at significance level of

$p < 0.01$. Results showed that the vendors were in two categories, owner and employed. On socio-demographic characteristics of gender, the female vendors were more than the male, at 52.5%. The female owners were more than the males at 32.5% against 22.5%. On age, majority vendors were between 36 to 50 years, with male vendors being more at 27.50%. Female owners were slightly more at 15.0% against males at 10.0%.

On marital status, married vendors were the majority with females equal to the males. The female owners were more than the males at 20.0%. On education level, majority vendors were of tertiary level at 45.0%, with the females being slightly more at 25.0%. Female owners were more than male owners at 20.0%. Moisture content of the market peanuts varied between 5.2 – 8.4% with mean of 6.5%. Of the samples, 25% had moisture contents slightly above the optimum for storage of 8.0%. The aflatoxin contents varied between 3.3 – 38.5ppb with mean of 14.8ppb. Up to 45% samples had levels of aflatoxin above tolerance of 10ppb. Treatment of the peanuts with cold water, warm water and warm calcium hydroxide managed to reduce the aflatoxin contents to well below the tolerance in less than 5 minutes, the most effective was soaking in the calcium hydroxide. UV irradiation also reduced the aflatoxin levels to below the tolerance in slightly under 2 hours.

Results conclude that vending of peanuts is by both males and females of mainly middle age and tertiary level education. The mean moisture content of the market peanuts almost complies with the tolerance, but the mean Aflatoxin content is well above the tolerance.

However, the aflatoxin levels can be lowered effectively to below the tolerance by soaking in cold water, warm water and warm calcium hydroxide and more effectively with calcium hydroxide solution. Irradiation with UV reduces the aflatoxin to similar levels in slightly less than two hours.

CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND.

Early in 2019, Kenya Bureau of Standard recommended withdrawal of some brands of locally manufactured peanut butter from the market because they contained aflatoxin levels higher than the national tolerance of 10ppb. The problem was traced to the raw peanuts which contained such high levels of aflatoxin that even after roasting and shelling, the levels of the toxin in the peanut butter produced therefrom was still higher than the tolerance. The other forms in which peanuts are consumed in Kenya include the roasted with shell in various variants, the roasted and shelled and as flour from raw peanuts in a mixture with cereal flours for use in porridge preparation. These products obviously contain higher levels of the toxin than the tolerance (Wagacha *et al.*, 2013). It is shown that roasting does not reduce aflatoxin levels in peanuts substantially (Martins *et al.*, 2017). The nuts shelled with machine also does not lower the toxin to below the tolerance due to the intermixing of the shell and kernel during shelling so that the former contaminates the latter. Reports indicate that many of the peanuts and peanut products analyzed in Kenyan markets do not meet the standards in terms of Aflatoxin levels (Mutegi *et al.*, 2013). Specific levels of aflatoxin in peanuts from Kenya have been reported to be from 0 to 7525pbb (Mutegi *et al.*, 2009).

Levels of up to 513ppb of other peanut products were also reported during a study conducted in Taiwan (Chen *et al.*, 2013).

The reports from KEBs also, indicate that the peanuts products produced by the locally manufactured in Kenya mainly the peanut butter is heavily contaminated with the toxin. (Lubanga and Bii, 2019). Roasting, however, either oven or microwave has been reported not to lower the aflatoxin content significantly (Mobeen *et al.*, 2011). During machine shelling, some aflatoxin is likely to be transferred from the shells to the cotyledons thereby being transmitted to the peanut butter. This way also the market roasted and/or cleaned peanuts will have aflatoxin levels possibly higher than the tolerance of 10ppb.

The most practical solution to this problem is reduction of the aflatoxin in raw peanuts to the tolerance or below prior to roasting. This can be done by applying the clearly known treatments like exposing the peanuts to Ultra- violet irradiation, flash washing with cold or warm water, flash washing of the peanuts with hot water containing Calcium Hydroxide. Cooking in alkali (Nixtamalization) has been found to reduce levels of aflatoxin in maize substantially

(Elias-Orozco *et al.*, 2002). Peanuts and products are widely consumed in Kenya, but mainly as roasted peanuts and peanut butter. These products have been reported to have higher residual aflatoxin than the tolerance and therefore expose the consumer to Aflatoxicosis. The peanuts for the study were procured from vendors in the main Cereal Market in Nairobi which is Nyamakima market. Most of them are imported from Malawi and according to a study that was done in year 2013, the peanuts contain higher aflatoxin levels than the peanuts from other markets in the Country (Ndung'u *et al.*, 2013).

This study was designed to evaluate the effectiveness of specific treatments which include soaking in water, soaking in lime (calcium hydroxide solution) and irradiation with UV to lower the total aflatoxin levels to below the tolerance of 10ppb prior to roasting.

1.2 PROBLEM STATEMENT

The aflatoxin content of Kenyan peanuts is reported to be much higher than the national tolerance. Commercially processed products like peanut butter and roasted shelled peanuts have been reported to have higher residual aflatoxin than the tolerance where this indicates that roasting and shelling during commercial processing does not seem to reduce the levels of aflatoxin significantly (Ndung'u *et al.*, 2013). The processed products from roasted products like peanut butter, shelled and unshelled peanuts, therefore pose a danger of Aflatoxicosis to the consumer. Conventionally detoxification of peanuts is done by using physical removal of the contaminated peanuts, heat treatment, chemical or the radiation application ((Pankaj, Shi and Keener, 2018)*)*; However, detailed information on the application of these methods is scanty.

1.3 JUSTIFICATION OF THE STUDY

This study was carried out in Nyamakima Market because it is the main Cereal Market in Nairobi. Peanuts and products are widely consumed in Kenya, but mainly as roasted peanuts and peanut butter. Since, roasting does not seem to reduce substantially the aflatoxin levels, it appears that the only hope is to institute treatments that lower the toxin prior to roasting. The results of this study will have a number of beneficiaries that include: Government policy makers to develop policy on methods of production and manufacturing of peanut products that do not pose risk of Aflatoxicosis to the consumer. The researchers will gain data to help in the formulation of further research in the utilization of the crop.

Manufacturers will gain acquire the knowledge and technology to process produce peanut products with safe levels of aflatoxin and safeguard the trade. Finally, the consumers of the peanuts and the peanut and their products will have the safety confidence with the product.

1.4 OBJECTIVES

1.4.1 Main Objective

The main objective of the study is to assess the peanut vending environment in Nairobi and the effectiveness of pre-treatments prior to roasting in reducing the levels of total aflatoxin in raw peanuts to below the tolerance, with the view to the roasted peanuts and products to comply with the same.

1.4.2 Specific Objectives

1. To determine the social-demographic and the social-economic characteristics of the peanut vendors in the main markets in Nairobi Metropolis.
2. To determine the market characteristics of the peanuts in the main markets in the Nairobi Metropolis.
3. To determine the moisture and aflatoxin contents of the market peanuts
4. To evaluate the effect of specific pre-treatments of the peanuts prior to roasting in reducing the levels of aflatoxin content of raw peanuts.

1.5 HYPOTHESES

1. The peanut vendors are not characterised by Social-demographic and Social-Economic factors
2. The market characteristics of the peanuts are not different from one to another
3. The moisture and the Aflatoxin content of the market peanuts are not within the allowable limits
4. There is no effect on the specific pre-treatments of the peanuts prior to roasting in reducing levels of the Aflatoxin content of raw peanuts

CHAPTER TWO: LITERATURE REVIEW

2.1 THE PEANUTS: PRODUCTION AND UTILISATION

Peanuts (*Arachis hypogaea* L.) they are also known as the groundnuts it's a legume dicotyledonous herb that grows up above the ground to a foot level. They are small sized underground fruit pods. They are commonly referred to as the groundnuts or the earth nuts.

The crop grown is mainly for its edible seeds. The crop originated in Central America, through Spanish explorers, it did spread throughout the world. In Kenya, they are highly grown in Western area (Mutegi *et al.*, 2009).

They are the oil seeds that today is widely cultivated worldwide, mainly in tropics and subtropics being important to both small and large commercial producers. In Kenya, it has a positive impact on the Gross Domestic Product (GDP) where it gives a significant amount of it. However, the peanut production has predominantly increased at primary level (Wanyama *et al.*, 2013).

They are delicious and crunchy. They can be consumed as raw, roasted, mixed with other dishes or as peanut butter. They have nutritious benefits that has almost all required qualities of other edible nuts that are popular such as the almonds. For the peanut plant to mature, it takes for about 120 to 150 days to mature after the seed is sown. To harvest the crop, it involves the root being dug from the soil and each plant holding 10 to 150 pods where each pod contains thick outer shell wrinkles. Papery thin, brown layer covers the peanut kernel. The protein content in peanuts is high; hence there is high demand of adding them in to animal feeds to increase the nutrition value. According to (Davis and Dean, 2016), a kilogram of peanuts has approximately equal nutritional value as 2 kilograms of beef or 4 litres of milk.

The ground nuts are also rich in vitamins, Zinc and Iron. The qualities make the peanuts to be an important supplement worldwide. Food safety involves; food availability, its safety and affordability. This is according to FAO.

This ensures that the body gets only the nutrients that are required for the wellness and health. Consumers concerns are being catered for by the various conducted studies in the world in the matter of the food safety. According to (ASEAN Secretariat, 2019) food analysis has been done on mycotoxins analysis where Ochratoxins and Aflatoxins are the most significant mycotoxins. Aflatoxin poisoning occurs due to poor storage facilities where the moisture content is above the recommended levels and intake of insect damaged cereals. Aflatoxin mostly occur in third world countries where the safety of food has a low compliance from the food suppliers in local markets which do exist in large numbers.(Gordon S. Shephard, 2008).

Feeds and the cereal based cultural products are the most products that are invaded by Aflatoxins. This leads to reduction of the yields, food quality and productivity (Lukwago *et al.*, 2019). According to FAO, 30 to 60% of foods are contaminated with aflatoxin in 10 years, posing the aflatoxin as so significant in food security and also in the economy (WHO, 2006). There is a great health effect of Aflatoxin intake across the sub-Saharan Africa. In humans, the effect is from acute hepatic impact to chronic toxicity impact (G. S. Shephard, 2008).

To the animals, liver damage, reduced reproduction, milk production reduction and suppressed immunity is caused by taking low concentrations. Acute toxicity leads to decreased feed intake and efficiency, gastrointestinal defects, jaundice, drop in milk production, nervous signs, loss of weight, bleeding and eventually death (Trujillo *et al.*, 2006).

Poor transportation facilities, storage, moisture content, high temperatures and heavy rains are the factors that lead to invasion of aflatoxin in most Africa countries. Poor aeration, dirty floors promotes fungal growth on wet kernels. (Robertson-Hoyt *et al.*, 2007). There are no enough measures in Sub Saharan Africa to enforce food safety regulation towards reduction of aflatoxins. This is leading to many people get exposed that finally leads to serious health issues. The products are rejected for exports leading to economic loss.

2.1.1 Peanut Processing

2.1.1.1 Peanut Production and Utilisation in Kenya

In Kenya, peanuts are used for oil production, peanut butter, confections, roasted peanuts and in production of snack products. Peanuts are considered as a popular traditional cereal food in Kenya. After the value addition, either through roasting or making of the peanut butter, they are distributed to all shopping store country wide making them available for many people. This makes them gain popularity and its market has become so wide. In the streets, the peanuts are sold in small dimensions where the vendors just roast, some add flavours then they package ready to sell. Due to their ability to give nutrients in multiple, they are considered a go-to snack when compared to other type of snacks.

Also, they are milled together with other flours to increase the nutrition properties. To the animal feeds, they are also added due to their high protein content.

2.1.1.2 Shelled and Unshelled Peanut Processing

Shelled peanuts are regularly consumed in Kenya in their dishes and foods even though it is well known to be very susceptible for contamination of Aflatoxin. A study that was done in 2001, showed that the shelled peanuts had accumulated Aflatoxin to up to 42ppb.

Also, lack of skilled techniques may facilitate to the accumulation of the Aflatoxin in the shelled peanuts which may lead to cross-contamination of the Aflatoxin from the peanut shells to the kernel (ITOH *et al.*, 2001). Shelled peanuts are processed through scrubbing off the peanut skin where the Aflatoxin from the coat contaminate the already shelled peanuts.

Hence efforts should be installed in ensuring the safety measures that should be put in place to reduce contamination of the peanuts during the shelling process. The unshelled peanuts are highly considered for the intake compared to the shelled ones. This is because the peanut coat contains high levels of the nutrients (Okello *et al*., 2010). Therefore, measures should be put in place to ensure that there is no contamination of the unshelled peanuts so as to facilitate their consumption safety.

2.1.1.3 Peanut butter manufacturing

Peanut butter is a food inform of a paste made from dry roasted peanut mostly used as a sandwich spread that it has high protein and lipid contents. Also, it forms constituent of ready-to-use therapeutic food that is given to HIV/AIDS patients and under malnutrition in children, in the countries that are developing. The peanut butter raw material, peanuts are highly prone to aflatoxin contamination where are subjected to secondary carcinogenic (ITOH *et al.*, 2001). Consumers are protected from the harmful effects of Aflatoxins, where establishment of regulation in developed nations, enforcement of the set regulations in developing countries several factors, including unavailability of relevant analytical facilities and lack of skilled personnel hinders. Peanut butter might be highly contaminated with aflatoxin than the peanut grain because, unlike with the grain, it is impossible to decide on the quality of peanut butter by use of vision.

Quality of grains can be discerned by seeing, sorting the peanuts that are shrivelled, broken, undersized, the one that contain the mould and insect damaged.

Therefore, efforts to mitigate are needed and should be relied on data from markets on current aflatoxin levels of contamination. Aflatoxins are carcinogenic secondary metabolites that are toxic where fungi *Aspergillus parasiticus* and *Aspergillus flavus* produces it. Specific humidity, oxygen pressure temperature, enhances the production of these secondary metabolites (Hell and Mutegi, 2011). Food or animal feedstuff contamination with aflatoxin is a major problem in animals and human in the whole world.

2.2 AFLATOXIN: AN OVERVIEW

2.2.1 Aflatoxin in Peanuts and Products

Aflatoxins have the mutagenic, tetragenic and carcinogenic impacts; where their involvement in human food chain is a threat to public health due to its capability to invade a wide range of commodities (Magnussen and Parsi *et al*., 2013). The molds producing the toxin can infect agricultural crops during pre-harvest and along the whole post-harvest value chain, including drying, storage and/or processing (Wu, Khlangwiset, & Shephard, *et al.*,2011).

Therefore, monitoring regularly of toxigenic fungi in foods that are agricultural based is an important step in developing of strategies to prevent or to control the exposure of Aflatoxin in humans. Although there are reports of aflatoxin epidemics in the western parts of Kenya, contamination of aflatoxin is almost never controlled in food stuff (Macmillan, 2004; Okoth *et al*., 2012). An outbreak of human acute aflatoxin poisoning involving 317 cases with 125 deaths was reported in Kenya in 2004.

The epidemiologic investigation attributed this to consumption of contaminated maize (Lewis *et al.*, 2005). This brings to focus the potential danger of such contaminated cereals getting into human industry in Kenya. For the protection of public health, regulations for the allowed level of aflatoxins in foods has already been established. Their chemicals are highly toxic to humans and animals (Wu et al., 2014), contamination of agricultural crops worldwide was estimated to be 25% in 2010 (Sarah, 2011).

Molds are highly resistant to agents that are used to kill other molds hence they can be in food for long. Therefore, monitoring regularly of toxigenic fungi in the agricultural foods is important for management strategies development to control aflatoxins exposure of food and animal feeds.

2.2.1 Aflatoxin in Peanuts Traded in Kenya

In Nyanza province markets, where the peanuts are an integral meal, high levels of Aflatoxin have been detected posing a threat to the human health disorders (Ndung'u *et al.*, 2013). High levels of Aflatoxin which are continuously increasing has been reported in post-harvest samples of peanuts (Kaaya and Kyamuhangire, 2006), which could also be the case in the peanuts in Kenya though in Kenyan market level, there is no much information on Aflatoxin contamination (Mutegi *et al*.,2010). Such information would inform the farmers, traders and manufacturers that would help them to improve the marketing potential, pricing, creating the demand to the consumers on for the safe products and also in the review of the standards in regulation of the Aflatoxin intake in the peanuts. High levels of Aflatoxin in peanuts has seriously affected the International market where Kenya export business has seriously been affected (Muthomi *et al*.,2008).

2.2.2 Aflatoxins in Peanut Butter

The raw materials for the peanut butter, the ground nuts, are prone to the Aflatoxin contamination, the secondary metabolites of the fungi. As a measure to protect consumers from the harmful effects of aflatoxins, regulations are established by the government bodies. Regulations enforcement in developing countries is challenged by several factors, including lack of skilled personnel and availability of analytical facilities that are relevant. Foodstuffs and peanuts and peanut products that are sold in these countries might contain high aflatoxins aflatoxin.

In such cases, peanut butter might be more contaminated than the peanut grains, unlike with the grain where it is impossible to make a decision on the quality of peanut butter by sight. Broken groundnuts and insect damaged can be visually discerned and sorted out.

Peanut sorting, reduces grains aflatoxin contamination. Peanut butter do not have any sign of moulds and so no one can tell if the grain used was mouldy, contaminated or insect damaged. Hence, mitigation measures therefore are needed where current levels of aflatoxin contamination data from the markets is used to guide.

Greater attention has been paid to aflatoxin than any other mycotoxins because of their potential to contribute to carcinogenic effect and their acute toxicological impact in humans. Due to increased consumer awareness and demand for transparency concerning the Aflatoxin in peanut butter, the industries have enforced regulations in the manufacturing process in order to reduce Aflatoxin levels which impact in mitigating the effect.

There have been cases concerning Aflatoxins in Kenya. The major one involved the calling back from the market of Nuteez peanuts a product from Jetlack company early in the year (2019).

According to the Kenya Bureau of Standards, the peanut brand contained higher than recommended levels of aflatoxins. Following the withdrawal of operating licence of the company, where it should not operate in any processing or selling of the product.

This will contribute to significant economic losses. Also, the country cannot export the product due to these toxins. A study was done in Nairobi, Western and Nyanza Kenya was done where the products were sampled from the selling points. 37% of the samples were found to have aflatoxin levels above 10ppb which is above the set limits by Kenya Bureau of Standards (Wagacha and Mutegi, *et a*l.,2013).

Samples of peanut butter were collected from Kenya selling stores and levels of Aflatoxins ranged from 0 to 2377.1 ppb (Ndung'u *et al.*, 2013) The need of this study was to alert the peanut butter manufacturers that mitigation measures needed to be put in place so as to reduce the Aflatoxin levels in the product.

2.2.3 Methods of Reducing Aflatoxins in Peanut Processing

At pre- and post-handling stages, there are chances of aflatoxin contamination in peanuts where integral management has to be applied at all stages to reduce the toxin (Torres *et al.*, 2014).

Management practices that are ineffective, climate conditions that are unfavourable during and after harvesting contributes to pre and postharvest aflatoxin contamination. Ambient temperatures leads to mould infestation on grains (Muthomi, Gathumbi et al 2009).

To reduce postharvest losses, it is advisable to enforce food security measure which will increase the food security (Kimatu *et al.*, 2012).

The above factors surrounding peanuts production lead to the management practices to ensure safe produce with minimal aflatoxin levels in the peanut production industries. These control measures include; Enhancement of Good post-harvest Practices, Good Manufacturing Practices and Good Hygiene practices.

2.2.3.1 Physical methods

Manual or electronic sorting hinders aflatoxin contamination where during the processing seeds required for consumption. Mouldy, discoloured or shrivelled seeds are discarded (Hell and Mutegi, 2011). In developed countries they practice artificial drying (Wu and khalingswet *et al*.,2011) where it reduces moisture content in peanuts up to 12% hinders aflatoxin producing fungi.

Other methods of drying include the sun drying on the mats. New methods of storage; permanent or the temporal includes metal bins which offer more improvement than traditional method.

Adoption of the new methods by small scale manufacturers is limited to resources due to high cost (Hell and Mutegi *et al*, 2011). Reusing of the clean bags enables use of spore free storage. (Awuar,2000, Hell *et al*,2011). Airtight hermetic triple bags improve crop storage and prevent groundnuts from mould growth and aflatoxin contamination (Williams *et al*., 2014). Better storage maintains the quality of the produce hence farmers determines the prices which is economically advantage (Kimatu *et al.*, 2012). A study done by (Bahkali *et al.*, 2012), shows that the physical methods has less effect in reducing Aflatoxin to tolerable levels.

2.2.3.2 Electromagnetic radiation treatment

To maintain good quality of agricultural products, Gamma (γ) radiation is considered in preservation (Jalili, Jinap and Noranizan, 2010) where the DNA in microbial cells is damaged by high energy photons produced by the rays. The use of the UV radiation in reduction of the

Aflatoxin has been proved to be impactful where it is widely used in the treatments of cereals prior to storage. ('Assessment of Aflatoxin Level in Stored Wheat of Godowns of Hyderabad Division and Decontamination by UV Radiation', 2016)

2.2.3.3 Chemical methods

Use of citric acid resulted to aflatoxin B_1 degradation (Méndez-Albores, Del Río-García and Moreno-Martínez, 2007). (Jalili and Jinap, 2012) studied on the effect of sodium hydrosulphite ($Na_2S_2O_4$) where reduction of aflatoxin B_1, B_2, G_1, and G_2, was discovered with no impact to damage of black pepper's out layer.

Soaking of organic acids to reduce Aflatoxins in soybean (Lee, Her and Lee, 2015) shows a high reduction of aflatoxin B_1 from tartaric acid, citric acid, lactic acid, and succinic acid.

2.2.4 Tolerable Levels of Aflatoxin in Peanuts and Products

The FDA 2015 offers guidelines with respect to law analyses raw agriculture products of aflatoxins. With this ,many countries regulates mycotoxins by setting tolerable limits for the presence of toxins in foods (Hell and Mutegi, 2011).

The international set limit standards in peanuts is 20ppb. While in Kenya, the regulatory limits of aflatoxins set by KEBs in peanuts is 10ug/kg (Mutegi *et al.*, 2013).The regulations vary depending on whether the country settings limits is an exporter or importer and they differ from nation to nation (Wu and Guclu, 2012). The FDA, an agency that ensures food safety of the national domestic produce and that is imported. It involves strategies to enforce the act of setting regulation limits, monitoring, guarding the food industry and cooperating with other agencies on food safety issues.

2.2.5 Aflatoxin in Peanuts Products in Kenya

The peanut marketed in Nairobi that are processed in the Kenyan industries and its aflatoxin contamination status has not been documented. Hence the peanut marketers and processors are supposed to be asked for information on the peanut sources.

Peanuts in Nairobi were imported from Malawi and others were grown from Nyanza and the Percent mean of the defective nuts and peanut butter were higher for Nairobi samples than that of Nyanza. Aflatoxin levels in all the samples were ranging from 0 to 2377.1 ppb. The aflatoxin level mean was higher for raw peanuts from Nairobi than Nyanza hence the peanuts source and defectives were strongly associated with aflatoxin levels. (Ndung'u *et al.,* 2013).

Inspection mechanisms and imported peanuts inspection should be well practiced and the use of well effective monitoring for aflatoxins standards compliance.

In another study which involved 1263 vendors of the peanuts in various outlets from Nyanza and Nairobi provinces, 37% of the samples tested aflatoxin levels above the required limit of 10ppb.(Mutegi *et al.*, 2013). All the market players are supposed to sort their peanuts before selling or processing them so as to reduce aflatoxin contamination of peanut butter.

2.3 FACTORS THAT LEAD TO AFLATOXIN ACCUMUILATION IN PEANUTS

2.3.1 Physical Factors

Peanuts (Arachis hypogea L) are grow in different types of soils. *Aspergilus flavus* will take advantage of growing in light sandy soil especially during the dry conditions. (Guarro *et al.*, 2004). Also climate change has effect on the aflatoxins growth. (K.C., B.G., & P.J *et al* 2005). Some areas experiences decrease in precipitation and increase in temperature which would result to seasons.

Availability of water and temperature changes affects the genes growth rate to produce aflatoxin in *A. parasiticus and A. flavus.* Increase in production of aflatoxin B1 occurs when there in high ratio of interaction between water activity and temperature (Medina *et al.*, 2015). Causes like physiological stress and insect damage facilitates fungal growth. High humidity leads to contamination with aflatoxins while the food is in the field and in the storage. Fluctuations in climate facilitates the host to contaminate where the crop growth is altered hence the host creating wounds where the Fungi producing aflatoxin multiplies in (Cotty and Jaime-Garcia, 2007). Therefore, there is a need to control the water activity of the grains to reduce the moulds growth.

2.3.2 Chemical Factors

Areas sprayed with none insecticides that are inoculated, plants that are densely populated, reduced fertilization has an influence of aflatoxins contamination (Klich, 2007).Improper agricultural practices such as increase in fertilizer application, increases the incidence of contamination of *Aspergillus flavus* in peanuts (Tortes *et al*., 2014).

2.3.3 Biological Factors

The growth of the *Aspergillus* in peanuts is facilitated by other factors which include the increase in temperature and moisture in the stored peanuts. During the harvesting process, contamination occurs where the moulds contaminates the peanuts.

When the conditions favours, the fungal growth accelerates and this leads to more accumulation of the *Aspergillus.* To ensure that the mould growth is not accelerated, proper storage temperature and moisture content is required which includes the use of improved storage bags (Williams, Baributsa and Woloshuk, 2014).

2.4 AFLATOXIN AND HUMAN HEALTH

Production of aflatoxins is facilitated at different points of the food chain including transport, storage and processing and it's a great threat to food safety(Lewis *et al.*, 2005). The aflatoxin health effects vary widely from acute to chronic impacts and also can lead to death. Acute toxicity is caused by high doses of aflatoxin is ingested at once or within a short period of time (Nyikal *et al.*, 2004). The toxicity effect of the aflatoxin in animals and human beings depends on age, sex and type of species, ingestion, concentration and the duration of exposure.

The Aflatoxins are very highly soluble in lipids hence they tend to be absorbed faster in the exposure side, usually the gastro intestinal tract to the blood stream (Santini *et al.,* 2013). The ruminants animals show the properties of the resistance to Aflatoxicosis more than monogastric species (Hussein & Brasel *et al* 2001)). Vomiting edema, jaundice, vomiting and Hepatitis and eventually death are some of the aflatoxicosis effects (Nyikal *et al* 2004). Aflatoxin metabolites reacts negatively to cell in inhibiting protein synthesis, lipids and carbohydrates. Liver being the main target organ, its function decreases that eventually lead to death.

In 2004, there was aflatoxicosis outbreak that was reported where 125 people died, and 317 cases were reported. (Lewis *et al.*, 2005). Chronic aflatoxicosis, is caused by intake of small doses of the aflatoxin over a period of time that leads to accumulation in the body.

They have carcinogenic and immunosuppressive effects that lead to stunting in young children (Gong *et al* 2002). When the jaundice effect manifest in the body, the liver starts, the T cells and the vitamin K decreases. This can also lead to liver cirrhosis and can also affect reproduction (Cousin *et al*., 2005).

2.4.1 Toxicity of Aflatoxins in Humans

Aflatoxins have been emphasized greatly in reaction to toxicity mechanism. The metabolism, DNA, mutagenicity, carcinogenicity has been studied thoroughly by the development of Aflatoxin biomarkers and biological effect (Eaton and Gropman ,2004) where in many parts of sub-Saharan Africa where aflatoxin exposure to human is associated to high risk of hepatocellula carcicoma (HCC) with combination with hepatitis b virus (HBV) (IARC ,2002). Its impact is on either humans or animals depend on duration and time of exposure. Acute exposure will lead to aflatoxicosis that rises as severe acute hepatotoxicity that can increase the fatality rate of about. The symptoms of Aflotoxicosis include; anoexia and low grade fever. Vomiting, abdominal pain, jaundice, hepatic failure and eventually death thought are some of the high level of acute stages of exposure of aflatoxin (Kamala *et al.*, 2018).

Rationally in immunologic suppression, impaired growth, and nutritionally interference are some other effects of chronic exposure to aflatoxin (Clerk, 2004). Daily exposure estimates due to aflatoxin outbreak have been studied where the aflatoxin intake ranged between 1.19 to 5.79 ppb. (Park, Kim and Kim, 2004).

Reduced efficiency in immunity to children has been brought up due to exposure of Aflatoxins hence risk of getting more infections(Gong, Watson and Routledge, 2016).

The abnormalities in the functioning and the structure and of mitochondria DNA and brain cells has been observed. (Verma, 2004). The review on the effects of aflatoxins on brain chemistry has also been done (Bosa *et al*., 2013).

2.4.2 Awareness on Aflatoxin by the Consumers

In creation of awareness intervention strategy on aflatoxins there is need to disseminate relevant information to people. In Kenya, many outbreak incidences have been reported. Also individual have reported to have received information on post-harvest activities through awareness campaign that was implemented by FAO, Ministry of Health and Ministry of Agriculture had lower reporting of aflatoxin exposure compared to those who didn't receive the information (CDC,2005). As per the objectives of the Government of Kenya policy on food safety standards and quality is to ensure safe and high quality food that is free from any food hazard. Through the creation of public awareness, there is less exposure of the Aflatoxin hence supporting the awareness strategy on very relevant issues by settling, promoting and enforcing appropriate guidelines, standards, and regulatory framework (KEBS, 2011).

2.4.3 Aflatoxins Levels in Consumption and Regulation

An estimate in annual peanut production in Kenya, is around 19000 tonnes (FAOSTAT, 2012). In Food Drug and cosmetic Act 402(a) food is said to be adulterated if it contains any poisonous or deleterious substance which may lead to health injury. For this reason, FDA 2015 gives directions according to law that emphasizes on analysis of agriculture products of aflatoxins levels.

Mycotoxins regulation has been set by many countries by setting tolerable limits in foods. (Shepherd *et al.,* 2008).The set limit standards internationally in peanuts is 20ppb.In Kenya ,the regulatory limits of aflatoxins set by KEBs in peanuts is 10ppb (Mutugi *et al*,2008).

The country settings limits to an exporter or importer which leads to the changing of the regulations (GARNET E WOOD).The FDA involve strategies to implement and enforce the act of regulation setting of limits ,monitoring to ensure compliance ,guidance giving to food industries together with cooperating with other agencies on food safety issues.

2.5 METHODS OF ANALYZING AFLATOXIN IN FOOD PRODUCTS

Several methods are available for analysing aflatoxin in food and feed. They include;

2.5.1 Electrochemical Techniques

Aflatoxin can be measured using electricity and electrochemical immuno-sensors that consist of double electrodes (measuring and reference), where the measuring electrode is normally coated with specific antibodies that retains interest aflatoxins in the sample, whereas the other Electrode (reference) made of a combination of Ag / AgCl. The procedure for measurement is the same to, that carried out by the ELISA test.

2.5.2 Chromatography

Chromatography is commonly used to analyse mycotoxins that include Aflatoxins.

The techniques of chromatography commonly used are Gas chromatography (GC), Liquid chromatography (LC), High performance liquid chromatography (HPLC) and Thin layer Chromatography (TLC), LC and HPLC being the most commonly used where they are followed by fluorescence detections stage (Cavaliere *et al.,* 2006).

LC, TLC and HPLC quantitative methods being highly used in research and analysis of aflatoxins (Vosough *et al*., 2010).

2.5.3 Enzyme Linked Immunosorbent Assay (ELISA)

This is achieved through labelling the Antibodies or the Antigens with Enzymes. This is incorporated by the preparation of Enzyme- Antigen conjugates and Enzyme- Antibody conjugates. This method has become the method of choice to many research institutions.

The method was designed for use in the optical density scanning mode which allows for the quantitative determination of Aflatoxin which is quick to read the Aflatoxin on site and can be used to motor day to day Aflatoxin level.

2.5.4 Radioimmunoassay

This method relies on the principle of competitive binding between the radioactive-labelled antigen and none-radioactive antigen. A known antigen quantity and labelled and unknown amount of un-labelled antigen from standards competitively react with a known and limiting the amount of the antibody. It is highly used in Aflatoxin analysis in food. The method has an advantage of the ability to perform multiple analyses simultaneously to a high level of specificity and sensitivity.

2.5.5 Lateral Flow Devices

Its principle is based on the use of high specificity and sensitivity of Antibody- Antigen reactions for the rapid detection of the analytes. Its sensors are capable of detecting Aflatoxin B1. It has a disadvantage in detecting all the mycotoxins due to their small sizes.

CHAPTER THREE: STUDY DESIGN AND METHODOLOGY

3.1 STUDY DESIGN

The study was cross-sectional in design with analytical component. Cross sectional design involved a baseline study where 40 vendors were categorized as owners and interviewed for the social-demographic characteristics of gender, age, marital status and level of education. Also, the social-economic characteristics only of the owner vendors was determined. Finally, the vending characteristics were also determined.

The analytical component consisted of the analysis of moisture contents and aflatoxin levels of the raw market samples of peanuts and the aflatoxin contents of the peanuts after going through the pre-treatments with cold and warm water, warm calcium hydroxide solutions of varying concentrations, and UV irradiation for different periods of time according to specific designs.

3.2 METHODOLOGY

3.2.1 Study Setting

Nyamakima Cereal Market is in Nairobi town, the capital city of Kenya. It is located in the city down-town as shown in the Road map of Nairobi Metropolis in Figure 1 where a lot of trade activities are practiced including the selling of cereals, and other grains and nuts. The peanuts selling set up, is open designed shops where they also serve as the storage of the stock peanuts. For the customers who were buying the peanuts in large scale, they were buying and carrying them in the storage polyethene bags and for the small-scale buyers, they were buying and carrying them in Kraft papers where the respective dimensions of sales were measured in.

Nyamakima Market

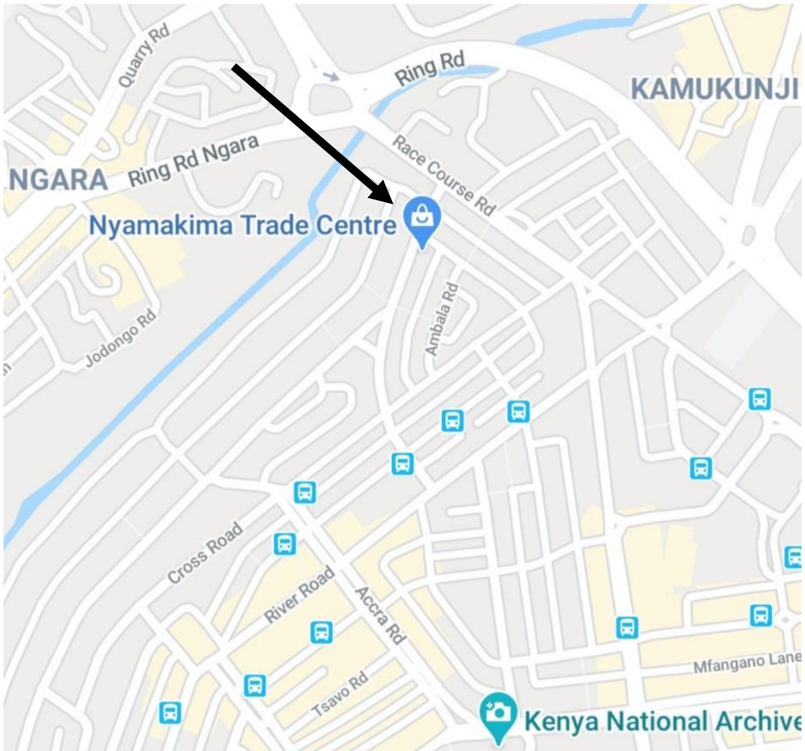

Figure 1: Road Map of Nairobi showing the Position of Nyamakima Market.

The sampling frame consisted of those vendors who sold peanuts only.

3.2.2 Population

The population of the study was all the peanut vendors in Nyamakima market.

3.2.3 Sample Size Calculation for vendors' survey

This was determined using a formula by Fisher et al (Fisher *et al*., 1991) as follows;

$N = z^2pq/d^2$

Where: z = the standard normal deviate at the required confidence level usually fixed at 1.96

P= The proportion of vendors with peanuts with Aflatoxin levels higher than the tolerance of 10ppb, taken as 50%

q = the proportion of the characteristic not having the characteristic being measured (1 – p)

d = the level of statistical significance set at 5% = 0.05

Therefore, N = $(1.96)^2$ (0.5) (0.5)/ $(0.05)^2$ = 385

Then sample was adjusted for population of less than 10,000 as follows;

The population of peanut vendors was 56

N f = required sample = Fisher/1 + Fisher/pop = 385/1 + (385/56) = 48.7 =48 vendors

The vendors who sold only peanuts was 40, less than the sample size calculated. Therefore, all the 40 vendors were included in the study.

3.2.4 Sampling of peanuts for analysis and pre-treatments

Out of the 40 vendors, 20 vendors were selected randomly by picking every other vendor. Then about 1 kg of peanuts was picked from each of the 20 vendors to constitute the 20 samples for laboratory analysis for moisture and aflatoxin, and the pre-treatments. The samples were then transported to the laboratories of KEBS for the procedures.

3.2.5 Data Collection Tools

For the baseline study, this consisted of a semi-structured questionnaire which was administered to the vendors to get information on social demographic, social economic and the vending characteristics of the peanuts to Nyamakima peanut vendors. For social demographic information, the vendors' age, marital status, education level was recorded. In each category, the ownership of the cereal stores was also recorded. For social economic information, the annual income for each vendor was recorded and categorised in terms of lower, middle, and high income earners taking into consideration of their marital status.

3.3 PRE-TREATMENTS OF RAW PEANUTS TO REDUCE AFLATOXIN

The following pre-treatments were applied to the raw peanuts to try and reduce the levels of aflatoxin: Cold water, warm water, Calcium hydroxide solution and UV irradiation.

3.3.1 Treatment with Cold Water

This treatment was carried out with cold tap water. The peanuts were passed through a 4 mm sieve to remove the small particles and debris. Then about 100g were accurately weighed and placed in a 1000ml beaker. Then 250ml of cold tap water and the peanuts were gently agitated with glass rod for the time 2, 4, 6, and 8 minutes respectively. The water was drained off and the peanuts dried of the surface water using paper towels. Then 50g were placed in a mortar and ground with a pestle to a fairly fine powder. Of the powder, about 20g were weighed accurately and analysed of aflatoxin.

3.3.2 Treatment with warm water

This treatment was carried out with warm water at 50 – 60^{o} C. The peanuts were passed through a 4 mm sieve to remove the small particles and debris. Then about 100g were accurately weighed and placed in a 1000ml beaker.

Then 250ml of warm water was added and the peanuts were gently agitated for the time 2, 4, 6, and 8 minutes. The water was drained off and the peanuts dried of the surface water using paper towels. Then 50g were placed in a mortar and ground with a pestle to a fairly fine powder. Of the powder, 20g were weighed and analysed for aflatoxin.

3.3.3 Treatment with Lime (Calcium Hydroxide)

Calcium hydroxide (lime) was prepared in water at concentrations of 0.01, 0.02, 0.03 and 0.04g per 100ml water.

Each time the solution was warmed to 50 – 60 ^{o}C and used for treatment of the peanuts just like with warm water. Treatment time varied between 1 – 4 minutes at intervals of 1 minute.

3.3.3 Treatment with Ultra-Violet Radiation

The peanuts were passed through a 4 mm sieve to remove the debris and the present foreign matter. Then 500g of the peanuts were weighed and were evenly spread on a black Polyethene paper at a monolayer grain spread. A UV radiation lamp with wavelength of 346 nm was subjected at 30 cm above the peanuts for up to 6 hours. Then samples of 50g of the peanuts were taken each hour for analyses of aflatoxin.

3.4 ANALYTICAL METHODS

3.4.1 Determination of Moisture

Moisture was determined in the peanut samples by AOAC methods (AOAC, 2011) as follows;

a) Sample preparation

The peanuts were passed through a 4 mm sieve to remove the debris and other foreign matter. About 20g of the peanuts were crushed and grounded into small sizes by the use of a motor and pestle and was then placed in a sampling bottle ready for moisture content analysis where about 5g were accurately weighed.

b) Determinant of moisture

Moisture content was determined by the use of the air oven where the temperature was set to 105 ^{o}C. The clean Aluminium moisture dishes were conditioned in the air oven for about 10 minutes and transferred into a desiccator to cool down to room temperature as it dried at a constant weight.

The empty dish weight was recorded, from the grounded peanut, 5g was weighed accurately into the Aluminium dish and was spread evenly for uniformity and placed into the air oven for a duration of 6 hours.

After the exposure time was over, the ground dried peanuts in the dish was removed from the air oven by the use of tongs and was put into a desiccator to allow it to cool at a constant weight. The dried sample and the dish were then weighed. Moisture content was expressed as the Percentage weight loss as follows;

Moisture (%) = (W1-W2)/W1*100

Where W1=Weight (g) of the sample before they are dried

W2= Weight (g) of the sample after they are dried

3.4.2 Aflatoxin Analysis

Enzyme Linked Immunosorbent Assays was the method used in Aflatoxin analysis as used in a study that was done in Kisumu Kenya ('Exposure of children 4 to 6 months of age to aflatoxin in Kisumu County, Kenya', 2015).

a) Sample preparation and extraction methods

The peanuts were passed through a 4 mm sieve to remove the debris and other foreign matter that was present. About 50g of the peanuts was weighed and crushed by the use of a motor and pestle that reduced the size to small particles. From the ground sample, 20 g were weighed in to a flat bottomed flask and it was ready for Aflatoxin extraction process. Methanol of 70% concentration was used as an extraction reagent and it was prepared by adding 30 ml distilled water in 70 ml Methanol. By use of the graduated measuring cylinder, each weighed sample in a flask was added 100 ml of the extraction reagent.

By use of an electric shaker, the sample was shaken for 30 minutes. Afterward, it was allowed to settle and filtered through a Whatman filter papers and the sample to be tested was collected in a sample tube and it was ready for Aflatoxin analysis.

b) Analysis

The reagents to be used were brought to room temperature from the preserving temperature of 2 to 8℃. Each sample and the standard to be tested was assigned to a single dilution micro well and set on to the holder. Equal number of the antibody coated micro titre wells were placed on another holder. 200µL of the Aflatoxin-HRP Conjugate solution (composed of conjugated peroxidase in buffer with preservatives) was dispensed in to each mixing well. By the use of a new pipette tip, 100 µL of each sample and the standard was added to each appropriate mixing well that has the conjugate.

By the use of the pipette and the tip, the solution was mixed thoroughly for at least 3 times and then a 100 µL from each mixing well was transferred to the corresponding Antibody coated Micro-titre well, then incubated for 15 minutes at room temperature.

Afterwards, the content was decanted into the wash sink and each micro well was thoroughly cleaned by filling each PBS-Tween wash buffer solution of about 6.8-7.0 pH, then decanting the buffer in to the wash sink. The washing was repeated for 5 times. The micro wells were tapped facing down on a layer of an absorbent towel to remove the residual buffer. 100 µL of the substrate solution (composed of stabilised tetramethylbenzidine) was added into each micro well by the use of the pipette and was incubated for 5 minutes while covering with an aluminium foil to protect from the direct light. 100 µL of the stop solution (Acidic solution) was added into each well in the same sequence and as the substrate solution was added.

The optical density (OD) was obtained from each well with a microtiter plate reader using 450nm wavelength filter and the OD for each micro well was recorded. A dose-response curve was constructed using the OD values which were expressed as percentage (%B/Bo) of the OD of the zero (0.0) against the Aflatoxin content of the standard. Unknown were measured by interpolation from the standard curve. The ratio of dilution of the samples was 5:1 in 70% Methanol hence the level of Aflatoxin shown by the standards were multiplied by 5 in order to indicate the Aflatoxin in ppb.

3.5 STATISTICAL ANALYSIS OF DATA

The data for social- economic and demographic characteristics of the groundnut traders was analysed in Statistical Package for Social Sciences (SPSS) version 25 (IBM, 2018). Descriptive statistics including frequencies, mean and standard deviation were generated for the social-economic and demographic characteristics and the handling, storage and packaging practices of the groundnut traders. Inferential statistics such as chi-square was used to test the relationship between trading practices and the social-economic and social-demographic characteristics of the traders. Linear regression analysis was used to establish the predictor effect of moisture content on the aflatoxin content of groundnuts. Significance was tested at $p<0.05$.

The laboratory data was analysed using R Statistical Package (R Core Team, 2019). Descriptive statistics of aflatoxin levels in the treated groundnuts were generated. Analysis of variance (ANOVA) was used to establish significant differences at $p<0.01$ in the treatments applied that had no quantitative measures in representation. The different means were separated using Tukey’s HSD test. For treatments that were in quantitative measures including time of UV exposure, predictor effect on aflatoxin content was established using linear regression test. Significance was tested at $p<0.05$.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 SOCIAL DEMOGRAPHIC CHARACTERISTICS OF THE PEANUT VENDORS

The social-demographic characteristics of gender, age, marital status and level of education are shown in Tables 1 – 4, where each characteristic is distributed in terms of the relationship to the business as owner or employee.

4.1.1 Gender of the Vendors

The gender characteristic of the peanut vendors is summarized in Table 1. The data is displayed by association with the business as owners or employees. The female gender constituted more than half (52.5%) of the vendors. This may be due to the traditional Kenyan culture that food is only to be handled by women. According to a study that was done, (Ahmed *et al.,* 2019) and (Rover and Skinner *et al* 2016), showed that there are more females than males in food vending. Another study showed that female vendors were 86%. (Eliku, 2016).

Of the male vendors, the employees were only slightly more than owners the businesses. On the other hand, of the female vendors, the owners of the business were significantly more than the employed vendors. It is assumed that the owners were engaged in the business as self-employment, while those employed had their employers engaged in other forms of occupations including salaried employment. Male business owners were more than female business owners.

Table 1: Distribution of vendors by gender and association with the business

Gender	Frequency	Percent
Female	21	52.5
Owners	13	32.50
Employed	8	20.00
Male	19	47.50
Owners	9	22.50
Employed	10	25.00

4.1.2 Age of the Vendors

The age groups of the vendors considered were 21 – 35 years, 36 – 50 years and 51+ years. The age group characteristics were also distributed in terms of gender and association of the business as summarised in Table 2. The vendors of the youthful age (21-35 years) and those of the age 36-50 years constituted 37.5% and 47.5%, respectively, and together constituted the majority vendors. The elderly (>51 years) constituted only 15%. The largest number of the vendors who ventured in to the business of peanut selling did so because they could not have skills for employment elsewhere. On a study that was done, majority of the food vendors were youthful where they were 53% of them (Adama, 2020) and 78% on another study (Hygiene Practices Among Street Food Vendors In Tamale Metropolis, 2015). This has shown that the youths have really ventured in employment to avoid idleness or else the level of unemployment has led them to seek for such employments.

Among the youthful age group of 21 – 35 years, female traders were double the male traders. The business owners among both the males and female vendors were almost the same number. There were more female business owners than males, and the female employed were more than the males. These results show that the youth are engaging in self-employment and even helping to create jobs. Those who employed vendors were probably in salaried employment or having more than just this business. Among the middle-aged vendors, female owners were more than the employed, while male owners were much less than the employed. This implies that women unlike the men prefer to run the business as sole, while the men prefer to employ vendors while they probably engage in other income generation activities including salaried employment.

Finally, among the traders over 51years old which constituted only three female traders and three male traders (15% of total), female owners were two and male owners the same number. The owners probably included those that had retired from employment, while the employed consisted of the unemployed youth. It has been established that the age of the individual, in this case the vendors, enhances the financial capability of an individual according to a study that was conducted in 2019. (Ramana & Muduli, 2019).

Table 2. Age of vendors by gender and association with the business

Age group		
21 – 35 years	**Frequency**	**Percent**
Females	10	25.0
Owners	5	12.50
Employed	5	12.50
Males	5	12.50
Owners	2	5.00
Employed	3	7.50
Total age group	15	37.50
36 – 50 years		
Female	8	20.00
Owners	6	15.00
Employed	2	5.00
Males	11	27.50
Owners	4	10.00
Employed	7	17.50
Total age group	19	47.50
Above 50 years		
Female	3	7.50
Owners	2	5.00
Employed	1	2.50
Males	3	7.50
Owners	2	5.00
Employed	1	2.50
Total age group	6	15.00

4.1.3 Marital Status Characteristics of the Peanut Vendors

The marital status of the vendor characteristics considered were only married, single or widowed. Cases of divorced were not recorded, Data on marital status of the vendors are presented in Table 3, where each category is split into female and male owners of business or employed. Majority of the vendors at 60% were married, 30% were single and only 10% were widowed. Most of the street vendors were married. This is different from what was observed by (Rahman *et al*., 2016) that single vendors are more (52.4%) than the married (47.6%).

In the married category, Female traders were equal to male traders where each category represented 30%. In the single category, the male and female were also equal where each category represented 15%. To the widowed, the female represented 7.5% compared to 2.5% male and in this case, female was more. Among the married vendors, the owners of the peanuts vending shops were 32.5% which was more than the employed vendors who represented 27.5%. To the singles vending category, the owners represented 17.5% which was more than the employed vendors which represented 12.5%. To the widowed category, the owners of the peanuts vending shops represented 5% which was equivalent to the employed vendors as shown in Table 3 below;

Table 3. Marital status of the vendors by gender and association with the business

Married

Marital status	**Frequency**	**Percent**
Females	12	30.00
Owners	8	20.00
Employed	4	10.00
Males	12	30.00
Owners	5	12.50
Employed	7	17.50
Total	24	60.00

Singles

Female	6	15.00
Owners	3	7.50
Employed	3	7.50
Males	6	15.00
Owners	4	10.00
Employed	2	5.00
Total	12	30.00

Widowed

Female	3	7.50
Owners	2	5.00
Employed	1	2.50
Males	1	2.50
Owners	0	0.00
Employed	1	2.50
Total	4	15.00

4.1.4 Education Level of the Peanut Vendors

The data on education level of the vendors are presented in Table 4. The education levels considered were no formal education, primary, secondary and tertiary. The data are presented as level of education by gender and relationship to business presented by gender. As Table 4 shows, majority of the vendors had primary school education and only 7.5% of the peanut vendors had attained the secondary level of education. To Female vendors who were actually the owners of the peanut shops, none received the None-formal education. 7.5% of the employed vendors who were specifically male who were employed, received a No formal form of education so there was no female in this category. 7.5% owners of the peanuts vending shops for both male and female, received the education of up to primary school Level, which is equivalent to the employed vendors. 15% owners of the peanut vending shops in two gender, received the education of up to secondary school Level compared to the employed peanut vendors who represented 17.5%. 32.5% of the owners of peanut vending shops received the education level of up to Tertiary level compared to the peanut employed vendors who represented 12.5% which is lower than the vending owners'. For those who has education level of up to tertiary level but employed in the vending of the peanuts, chances are that they are experiencing unemployment wave which led them to vending of peanuts. Its discovered that such vendors might be uncomfortable doing such work but they have no better option of obtaining the daily bread (Manisha Manikrao Nayab & Dr. Usha Verghese, 2018). A study that was done, showed that majority of the market food vendors (66%) had received formal education which included the primary, secondary and tertiary level of education (Hygiene Practices Among Food Vendors In Tamale Metropolis, 2015).

This showed that the vendors have knowledge of the food safety and handling in all stages until the food product get to the food chain. Also, it has been discovered that the education level determines and enhances the financial capability of an individual. (Ramana & Muduli, 2019).

Table 4: Level of Education of vendors by gender and association with the business

Level of education	Frequency	Percent
No formal education		
Females	0	0.00
Owners	0	0.00
Employed	0	0.00
Males	3	7.50
Owners	0	0.00
Employed	3	7.50
Total	3	7.50
Primary school level		
Females	3	7.00
Owners	2	5.00
Employed	1	2.50
Males	3	7.50
Owners	1	2.50
Employed	2	5.00
Total	6	15.00
Secondary School level		
Females	8	20.00
Owners	3	7.50
Employed	5	12.50
Males	5	7.50
Owners	3	2.50
Employed	2	5.00
Total	13	27.50
Tertiary Level		
Females	10	25.00
Owners	8	20.00
Employed	2	5.00
Males	8	20.00
Owners	5	12.50
Employed	3	7.50
Total	18	45.00

4.2 SOCIAL-ECONOMIC CHARACTERISTICS OF THE PEANUT VENDORS

The social-economic characteristics of the traders was assessed only on those who were owners (22 vendors) of the businesses. These were interviewed for their annual income, and the income used to place each in one of the three socio-economic classes in the Country. According to a study that was done by (Kenya National Bureau of Statistics, 2017), economic classes classified as Lower, Middle and High income earner, the Low income earners were classified as who earns Ksh 23,670 and below, the middle income earners; Ksh 23,61 to Ksh 119,999 while for the high income earners is above Ksh 120,000. As Table 5 shows, the total owner vendors constituted 52.5% of the total vendors, and majority of these were females at 32.5%. Majority of the owner vendors at 32.5% belonged to the middle class, and the females were slightly more than males. The employee vendors who constituted 47.5%, were all assumed to be of the lower socio-economic class as they were paid salaries close to the minimum wage in Nairobi. This means that out of the total, the vendors in the lower class constituted 57.5% of total. The financial capability of the vendors is determined by how much they get in the selling of the peanuts. A study that was done showed that the daily turnover significantly influences the financial capability of an individual (Ramana & Muduli, 2019). Since it has been discovered in this study that majority of the vendors are from middle class, their capital contribution in the business might be minimal and hence the government need to support them. It is discovered that in their activities of vending they creates a chain of employments from the farmers, transporters, which indirectly helps them to strive (Manisha Manikrao Nayab & Dr. Usha Verghese, 2018). The empowerment of such business activities enhances the growth of the economy too. (Syamsir, 2016).

Table 5. Socio-economic characteristics of the peanut vendors who were also business owners

Lower socio-economic class	Frequency	Percent of total sample
Males	1	2.50
Females	3	7.50
Total lower class	4	10.00
Middle class		
Males	6	15.00
Females	7	17.50
Total middle class	13	32.50
Higher Class		
Males	1	2.50
Females	3	7.50
Total higher class	4	10.00

4.3 DESCRIPTION OF THE PEANUT TRADE IN THE NYAMAKIMA MARKET

As it is described in table 6 below, There were two types of peanuts in the market, the red and the white. The red type of peanuts was the most traded (82.5%) whereas the white type was the lesser traded at 17.5%. The study was done just to access the market environment and the selling characteristics of the peanuts and not in relationship with Aflatoxin content in the sold peanuts hence there was no statistical analysis to test the relationship. Preference of the red type of peanuts was by 90.0% of the consumers. The peanut traders all faced price fluctuations due to seasonal variation. At the time of the study the prices of the red peanuts varied between KES 100 and KES 130 per kilogram, while the price of the white peanuts varied between KES 110and KES 140. Several factors have shown to affect the sale of peanuts which include; prices, and general features of the environment in which a farmer sells peanuts, including distance to markets and credit access (Florkowski et al., 2017). Up to 70.0% of the buyers purchase the peanuts for domestic consumption whereas the rest bought them for resale (10.0%) or processing (20.0%).

There are so many ways of the consumption of peanuts (List, 2016), though the type of the peanut did not seem to be associated with the purpose for which the consumers purchase it. The majority of traders (5.0%) dealt with the imported peanuts where the locally produced accounted for only 95.0%.

The traders stocked 1-10 bags (40.0%), 11-20 bags (47.5%) or 21-30 bags (12.5%) of the peanuts at any given period of time.

The peanuts vendors displayed for sale in open 50-kg Polyethene bags (75.0%) or in a kilogram craft paper bags (25.0%).

The consumers who buy less than 5 kilograms, their purchase is packaged in 1kg, 2kg or 5kg Kraft paper bags. Majority of the traders dried their new purchases of peanuts to conform with the national moisture tolerance of the crop (8%) before bringing to the market for sale. Up to 62.5% indicated drying the peanuts on a mat spread on the ground whereas the rest used a raised platform (35.0%), just spread on the bare ground (3.5%). Only about 20% of the peanuts vendors contracts the National Cereals Produce Board (NCPB) for drying. There are other methods that are discovered used in drying the peanuts that even lead to reduction of the cost of production apart from using the solar drying which include the use of real- time temperature monitoring parameters (Lewis *et al.,* 2015).

Table 6. Peanut trade description in the Nyamakima market.

Peanuts types	Values (%)
Red	82.5
White	17.5
Consumer Preference	**Values (%)**
Red	90
White	10
Price fluctuations	**Ksh per Kilogram**
Red peanuts	100- 130
White	110- 140
Reasons for the sale of peanuts	**Value (%)**
Domestic consumption	70
Resale	10
Processing	20
Peanuts source	**Values (%)**
Locally produced	95
Imports	5
Number of stocked bags	**Values (%)**
1- 10	40
11-20	47.5
21-30	12.5
Bags used for display	**Values (%)**
Polyethene bags	75
craft paper bags	25
Spread materials during sun drying	**Values (%)**
Mat spread on the ground	62.5
Raised platform	35
Bare land spread	3.5

4.4 MOISTURE AND AFLATOXIN CONTENTS OF THE MARKET PEANUTS

The moisture and aflatoxin contents of the peanuts are shown in Table 7. As these results show, the moisture contents varied between 5.2 – 8.4 %, with mean of 6.5%. The moisture contents were significantly different from each other at $P < .05$. The optimum moisture content for storage of peanuts to stop the growth of molds including the Mycotoxigenic molds is 8.0% according to the East African Standard (EAS 57:2006). Against this level only 5 (25%) of the samples were slightly above the tolerance moisture content (8.0 – 8.4%).

These values were, however, not significantly different from each other at $P < .05$. During storage for prolonged periods, it is possible that these 5 samples could easily effectively set up water activity levels that would encourage growth of aflatoxin producing molds if present. It is a requirement in Kenya that all market peanuts be dried to meet the legal requirements with regard to moisture content. Possibly most or all the peanuts had therefore been dried by the vendors prior to bringing to the market. It is most likely the peanuts as purchased from the farmers contain moisture contents well above the tolerance.

This is a problem for those processors who purchase the peanuts directly from farmers and store for long periods of time to await processing. The extensive mold growth not only produces aflatoxin but may lead extensive rotting. The peanuts in the farmer's stores may also accumulate aflatoxin due to the favourable conditions for growth of the Mycotoxigenic molds. The aflatoxin contents on the other hand varied between 1.6 – 38.5 ppb with mean of 14.8ppb.

The aflatoxin contents were significantly different from each other at $P < .01$. The tolerance for total aflatoxin in peanuts in Kenya is 10ppb. Based on this, the results indicate that 9 samples (representing 45%) had levels of aflatoxin higher than the tolerance (17.1 – 38.5%). The mean aflatoxin content of the samples was also higher than the tolerance. The highest level of aflatoxin found in this study is, however, much lower than the level reported in market peanuts of up to 2377.1 ppb (Ndung'u *et al.*, 2013) which is about 50-times higher than the levels obtained in this study. Those peanuts with aflatoxin contents higher than the tolerance when roasted and shelled and processed into peanut butter will yield products with aflatoxin contents higher than the tolerance.

Table 7: Moisture and aflatoxin contents of market peanut by vendors

Sample	Moisture Content (%)*	Aflatoxin content (ppb)*
1.00	5.5 ± 0.1^{a}	4.9 ± 0.0^{c}
2.00	5.2 ± 0.1^{a}	7.2 ± 0.7^{d}
3.00	7.2 ± 0.4^{cd}	29.7 ± 0.0^{h}
4.00	5.7 ± 0.1^{ab}	3.2 ± 0.0^{b}
5.00	5.4 ± 0.1^{a}	2.2 ± 0.0^{a}
6.00	5.8 ± 0.0^{ab}	3.7 ± 0.0^{b}
7.00	5.5 ± 0.1^{a}	3.2 ± 0.00^{b}
8.00	7.6 ± 0.1^{de}	17.1 ± 0.0^{f}
9.00	8.0 ± 0.2^{de}	38.5 ± 0.1^{l}
10.00	8.0 ± 0.2^{de}	15.6 ± 0.0^{e}
11.00	5.9 ± 0.8^{ab}	7.2 ± 0.0^{d}
12.00	6.2 ± 0.0^{ab}	19.7 ± 0.0^{g}
13.00	8.4 ± 0.2^{e}	35.5 ± 0.0^{k}
14.00	8.1 ± 0.0^{de}	32.5 ± 0.0^{j}
15.00	5.2 ± 0.2^{a}	31.7 ± 0.0^{i}
16.00	6.5 ± 0.2^{bc}	5.3 ± 0.0^{c}
17.00	5.7 ± 0.3^{ab}	5.1 ± 0.2^{c}
18.00	5.7 ± 0.0^{ab}	3.3 ± 0.2^{b}
19.00	8.3 ± 0.0^{e}	29.2 ± 0.0
20.00	5.9 ± 0.1^{ab}	1.6 ± 0.0^{a}
Mean	6.5 ± 1.1	14.8 ± 13.0

**Mean ±SD (N = 20). Values along the column having the same superscript are not significantly different from each other at P≤ .05.*

There was a positive significant correlation ($P < .01$, $R^{2=}$ 0.5035) between moisture and aflatoxin contents. A study that was done in 2016, (Pesavento *et al.*, 2016) showed a positive correlation too of moisture content and the Aflatoxin concentration.

4.5 EFFECT OF PRE-TREATMENTS ON THE AFLATOXIN CONTENTS OF RAW MARKET PEANUTS

Four different treatments were evaluated for their effectiveness to lower the aflatoxin contents of raw peanuts. They included cold water, hot water, calcium hydroxide (lime solution) and Ultra-Violet irradiation.

4.5.1 Effect of Treatment with Cold and Warm Water on Aflatoxin Contents

This treatment was carried out with cold tap water and warm water at 50 – 60^{o} C. The peanuts were sorted to remove the blemished and debris. Then about 100g were accurately weighed and placed in a 1000ml beaker. Then 250ml of water (warm or cold) and the peanuts were gently agitated for the time (time was 2, 4, 6, and 8 minutes. The water was drained off and the peanuts dried of the surface water using paper towels. Then 50g were placed in a mortar and ground with a pestle to a fairly fine powder. Of the powder, 25g were weighed and analysed for aflatoxin. The results of these analyses are shown in Table 8 below;

Table 8: Effect of treatment with water on the aflatoxin contents (ppb)* of the peanuts

Time (Minutes)	Cold water	Warm (50-60^{o}C)
0	15.56±0.02^{Ca}	15.56±0.02^{Ca}
2	11.68±0.00^{Cd}	10.52±0.00^{Cd}
4	9.77±0.00^{Cc}	6.40±0.01^{Cd}
6	6.30±0.01^{Ce}	2.67±0.00^{Cg}
8	4.31±0.00^{Cf}	Nd

*Mean$\pm SD$ $(N = 10)$. *Values with a similar uppercase letters followed by a different lowercase letter in the superscript are statistically different at P< .001*. nd-not detected

Besides dislodging of the aflatoxin, the peanuts also are cleaned of dirt and the microbial loads are reduced to render the product healthier and more wholesome. The type of water used and the amount time of soaking significantly influenced the level of aflatoxin (p< 0.01).

Use of warm water as compared with cold, resulted in to lower aflatoxin levels. Increase in time of soaking of peanuts also increased the reduction of Aflatoxin in peanuts.

Soaking the peanuts either with warm or cold water in 4 minutes reduced the Aflatoxin to below 10ppb. Soaking of the peanuts in warm water for more than 6 minutes achieved the lowest levels of Aflatoxin in peanuts ($P<0.01$).

4.5.2 Treatment with lime

Lime was used at concentrations of 0.01, 0.02, 0.03 and 0.04% in water. Treatment time varied between 1 – 4 minutes and data collected at intervals of 1 minute. The results of these treatments are shown in Table 9.

Increasing the concentration of the lime significantly ($P< .01$) reduced the level of aflatoxin. The greatest reduction of the Aflatoxin in peanuts after the 4 minutes of treatment (98.2%) was realized at a lime concentration of 0.04%. The time of soaking in lime did not significantly ($P< .01$) influence the level of aflatoxin reduction. The treatment time required to reduce the aflatoxin to the tolerance decreased significantly with the concentration of lime.

The time of soaking in lime required to reduce the concentration of aflatoxin peanuts to less than the tolerance of 10ppb decreased with the concentration of lime in percent. This time was 3 minutes at 0.01% lime and only 1 minute at 0.02 – 0.04%.

The recommendation is therefore that treatment for these time lime combinations would be adequate to reduce the aflatoxin level to way below the tolerance of 10ppb pre-roasting. The higher concentrations of lime should be preferred because the treatment would be able to add significant amounts of calcium, a crucial nutrient in the diet. All the roasted variants of peanuts and the products therefrom like peanut butter would therefore contain less than the tolerance of aflatoxin.

The clearance of the aflatoxin with the lime was more efficient than with the warm water. The rate of removal increased with the concentration of the lime and the time of treatment.

Table 9: Effect of treatment with lime solution on aflatoxin contents (ppb)* of the peanuts

Lime Conc. (percent)/Treatment time (Minutes)	1	2	3	4
Initial content of aflatoxin. (ppb)	24.0 ± 16.1^{Ca}	24.0 ± 16.1^{Ca}	24.0 ± 16.1^{Ca}	24.0 ± 16.1^{Ca}
0.01	13.30 ± 13.3^{Ca}	11.6 ± 11.6^{Ca}	3.2 ± 1.1^{Ca}	2.4 ± 1.3^{Ca}
0.02	5.73 ± 0.16^{Ca}	2.40 ± 2.5^{Ca}	1.36 ± 0.3^{Ca}	1.1 ± 0.0^{Ca}
0.03	3.63 ± 4.2^{Ca}	0.8 ± 0.1^{Ca}	0.84 ± 0.42^{Ca}	Nd
0.04	Nd	0.4 ± 0.5^{Ca}	0.5 ± 0.04^{Ca}	Nd

**Mean* $\mu \pm SD$ $(N = 10)$ *Values with a similar uppercase letters followed by a different lowercase letter in the superscript are statistically different at p< .01.*

Nd = Not detected

This is probably attributable to the fact that whereas water merely washes the toxin from the surface of the peanuts, additionally some aflatoxin is destroyed by the alkali. A study that was done in 2002, (Elias-Orozco *et al.*, 2002) reported effective reduction of aflatoxin by the use of Lime.

4.5.3 Treatment with UV Radiation

Continuous exposure of the peanuts to UV irradiation of wavelength 346nm from a UV lamp placed at 30 cm above the peanuts for 2, 4 and 6 hours yielded the results shown in Figure 2. The exposure significantly ($P < .01$) reduced the aflatoxin content of the peanuts. A change in time by one hour accounted for 64.6% reduction in the aflatoxin levels. A study was also done and it also showed that aflatoxin in peanuts was reduced as time increased (Jubeen *et al.*, 2012).

UV wavelength of 346nm was used and the regression line represented by $R^2=0.646$, $P= .01$, at 95% confidence interval, on the linear regression line (y=12.2 – 2.1x), y=10 the tolerance for total aflatoxin was attained at the time x=1.0. The level of aflatoxin fell below the tolerance after treatment for slightly less than two hours.

A study was carried out using peanuts which were spiked with aflatoxin to vary the concentration. The study showed a similar effect to the results of this study. The UV irradiation to the known aflatoxin concentration spiked in water but the UV irradiation doses also varied (Basaran, 2009).

Only one band of UV irradiation was available for use. The trial required treatment at different wavelengths and times of exposure to help optimize them to reduce the levels of aflatoxin to well below the tolerance. The use of UV irradiation to inactivate the aflatoxin, has been proven to be effective, however the degradation products of aflatoxins and their safety or toxicity has not been clear (Mao *et al.*, 2016).

Use of UV irradiation in treatment of storage cereals, was found to be the most effective method to reduce levels of aflatoxin in grains during storage from deterioration, hence providing safe food and also minimising the loss ('Assessment of Aflatoxin Level in Stored Wheat of Godowns of Hyderabad Division and Decontamination by UV Radiation', 2016). In this study, only a monolayer packing was applied.

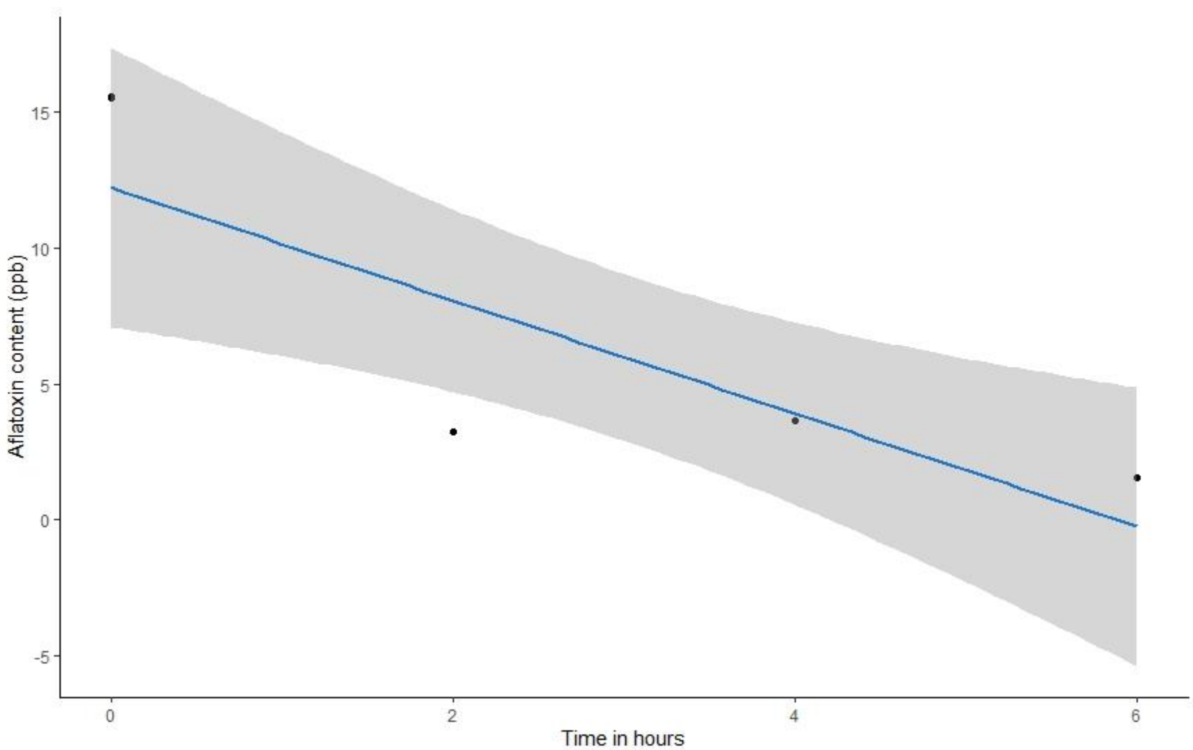

Figure 2: Effect of UV irradiation on the aflatoxin contents of the peanuts

For an effective reduction of Aflatoxin while using the UV irradiation, a thin layer spread of the cereals has shown to be impactful, where the decrease of the Aflatoxin levels correlated strongly with the thickness of the sample layer (Jabłońska and Mańkowska, 2014). In a practical commercial situation, more than a monolayer packing will be used. This might lead to an increase in the time for irradiation treatment to reduce the levels to below the tolerance, although this could possibly be counterbalanced by increasing the UV energy to optimum.

CHAPTER FIVE: CONCLUSIONS AND RECOMMEDITIONS

5.1 CONCLUSIONS

On social- demographic characteristics, this study has shown that the peanut vendors in Nyamakima market consisted of a normal characteristic of the population with both the males and females where there were more female than males, who consisted of owners and those who were employed in the peanut shops. Majority of the vendors were of mid-age, married and with tertiary level education.

On social economic characteristics, majority of the vendors were from the middle socio-economic class. This reflects that, the social economic characteristics in the vending of other cereals might also assume such characteristic also.

The mean moisture contents of the market peanuts was not significantly different from that recommended for optimum storage to prevent growth of toxin producing moulds, but the mean aflatoxin content was much higher than the tolerance, with about 45% of samples having more than the tolerance where the moisture content was positively and significantly correlated with the aflatoxin contents.

This was facilitated by the handling practices of the peanuts which included the drying techniques that the farmers used in the field were not adequate to dry off the peanuts which would led to their storage with moisture content higher than recommended. Also, poor harvest timing could also lead to invasion of molds due to rainy weather during the harvesting times.

The aflatoxin levels established in this study were fairly moderate, probably because they had been dried and almost complied with the optimum levels for storage, and therefore even in storage either in the farmer's fields or in the market stores, the Mycotoxigenic moulds would hardly grow to produce the toxin. Also, as compared to other studies that were done and data of Aflatoxin levels of the peanuts were obtained from Nairobi, each study gave independent data to show the levels also considering the time of study was different.

Observations would indicate that peanuts in Kenya peanuts are normally consumed after roasting at the domestic level in a griddle from clay or mettle. Using the same devices, the peanuts are also roasted for selling by street vendors, especially in urban areas like Nairobi. At the industrial level, the peanuts are roasted using commercial roaster to produce a variety of roasted peanut variants which are packaged for sale in the formal markets. At this level also the peanuts are roasted and shelled for manufacture of peanut butter.

It has been established that roasting with all types of roasters including microwave oven does not reduce the aflatoxin level very much, explaining the reason why Kenyan peanut butter has always been found to contain levels of aflatoxin higher than the tolerant. Obviously, the roasted unshelled peanut variants would be subsumed to have even higher levels of the toxin than the peanut butter.

The treatments with water and lime found to lower the aflatoxin levels in raw peanuts in this study are very simple would find very easy applicability at all the levels of processing indicated. Treatment of the peanuts with UV radiation reduced the toxin level to below the tolerance in slightly under two hours. Its use was found effective and would find application at the industrial level.

Treatment of the peanuts with cold water, warm water and warm calcium hydroxide solutions at concentrations ranging between 0.01 – 0.04% reduced the aflatoxin to below the tolerance in less than 5 minutes for all treatments. The treatments are easy and not expensive to implement and they showed a positive significance in the reduction of Aflatoxin. However, the effectiveness of reduction was in the order calcium hydroxide solution > warm water > cold water.

5.2 RECOMMENDATIONS

Further studies are recommended on the Ultra- Violet radiation treatment at different levels of insolation and more layers of grain packing. Also, studies should be carried out on the regeneration of the lactone ring after inactivation with the UV, especially to establish whether the regeneration takes place in the roasted peanuts and products. There is a need to train manufacturers and traders of roasted peanuts and products on treatments to be given to peanuts prior to roasting to reduce the levels of aflatoxin in the products to lower than the tolerances. Treatment with water and lime are simple and very practical and are therefore recommended for dissemination.

The Government should formulate a policy with regard to the postharvest handling and storage, and processing of peanuts to ensure that manufactured products as consumed contain levels of aflatoxin lower than the national tolerance of 10ppb. This can be done by being strict on drying the peanuts to moisture levels below 8% before storage and marketing, and using the treatments used in this study to lower the aflatoxin levels to lower than the tolerance before roasting or storage.

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APPENDECES:

APPENDIX 1: QUESTIONNAIRE

The aim of this study is to assess the details pertaining the peanuts sold to the peanut butter manufacturers. Your honest responses will be used for this research purpose only and shall be treated with utmost confidentiality. Your cooperation and participation is highly appreciated.

Thank you for accepting to take part in this study.

Date the form was filled (dd/mm/yyyy) __/__/____

Section A. Introduction

1. **Respondent's details**

- Interviewer's name;
- Vendor's name;

2. Social Demographic information (Tick where appropriate)

- **Gender**

Male

-Owners

-Employed

Female

-Owners

-Employed

- **Marital status**

Male

❖ Married

-Employed

-Owners

❖ Single

-Employed

-Owners

❖ Widowed

-Employed

-Owners

Female

❖ Married

-Employed

-Owners

- ❖ Single

-Employed

-Owners

- ❖ Widowed

-Employed

-Owners

- **Age**

Females

- ❖ 18-35 years

-Owners

-Employed

- ❖ 36-50 years

-Owners

-Employed

- ❖ 36-50 years

-Owners

-Employed

- ❖ Above 51

-Owners

-Employed

<u>Males</u>

- 18-20 years

-Owners

-Employed

- 36-50 years

-Owners

-Employed

- 36-50 years

-Owners

-Employed

- Above 51

-Owners

-Employed

- **Education level**
  - No formal education

Males

-Owners

-Employed

- Primary level

-Owners

-Employed

- ❖ Secondary level

-Owners

-Employed

- ❖ Tertiary level

-Owners

-Employed

- ❖ No formal education

Females

-Owners

-Employed

- ❖ Primary level

-Owners

-Employed

- ❖ Secondary level

-Owners

-Employed

- ❖ Tertiary level

-Owners

-Employed

3. Social Economic status (Tick where appropriate)

Male

- ❖ Owners
- ❖ Employed

Female

- ❖ Owners
- ❖ Employed

Annual Income levels

a) Lower income levels

- ❖ Male
- ❖ Female

c) Middle income levels

- ❖ Male
- ❖ Female

d) Upper income levels

- ❖ Male
- ❖ Female

Location

Town	**Location**	**Ward**	**Market**	**Vendor's market stall**

Section B: Selling of the peanuts

1. How many types of peanuts do you sell?
    a. Which is the most type of the peanut is sold?
    b. Is the most type of the peanut highly sold?
        i. 1-Yes 2-No
    c. If yes, what makes it get to be sold faster than the other?
2. What is the main purpose for the buyers to buy the peanuts?
3. Is the peanuts selling times seasonal?
    a. If yes, in which month(s) of the year? Also, where do they obtain the peanuts at off seasons?
4. Which are the most regions you buys the peanuts?
    a. Import

If are imported, which countries do they come from?

    b. Locally produced

If are locally produced, at what areas in Kenya did you obtain the peanuts?

a. After how much of stock remaining do you intend to add more?

b. Are the peanuts exhaustively sold off from the stalls?

c. After how long do all the peanuts in the stall are sold?

5. To whom do you sell your produce mostly?

Section C: Storage facilities of the peanuts in the market stalls

6. Immediately after buying the peanuts from the producers, where do you often put the peanuts?
7. How do you package them?
8. How is the produce transported to the market?
9. What proportion of your produce is spoilt before reaching the market?

What is the major cause for this?

1-Poor storage facilities

2-Long distance to the selling point

3-Contamination of produce

10. Are there practices you have learnt from other people on how to preserve the peanuts that you have not yet adopted?

Section D: Preparation of peanuts

11. What processing techniques do you apply prior to selling of the peanuts?

    In case of sun-drying, what do you do to your peanuts?

    1-Sorting, washing and blanching then drying

    2-Sorting and washing and drying

    3-Sorting then drying

12. On which surface do you dry your peanuts?

1-On the ground on the mat 2-On bare ground 3-On raised platform

SECTION E: Constraints in the selling of the peanuts in the market stalls

13. What major constraints do you attribute to peanut butter in this market?

(Tick as appropriate)

Constraint	**Extent** **(1=severe 2=moderate 3=low)**
Field pest	
Peanuts scarcity	
Poor yields	
Lack of market	
Poor varieties	
Extension services	
Low prices	

Price fluctuations	
Drought	
Diseases	
Access to seed	
Massive spoilage	

14. Which dimensions do you sell your peanuts in?

15. What is the pricing of peanuts in this market?

16. What other possible challenges would you relate to the selling of the peanuts?

17. Is there any other thing you would wish to share with us?

……………………………………………………………………………………………………

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THANK YOU FOR PARTICIPATING

Please note

No full stop after titles, subtitles, Table and Figure legends, footnotes, objectives