FOOD SAFETY, FROM FARM TO FORK

Emerging and Re-emerging Issues

Edited by

Juliana Kiio and Christine Njuguna

Food Safety, from Farm to Fork

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TABLE OF CONTENTS

INTRODUCTION

Global food security has been shaken by the many emerging and re-emerging issues of food safety concern. Scientific evidence indicates that unsafe foods are responsible for more deaths than malnutrition. Cancer and other foodborne illnesses, which have been attributed to unsafe foods, are on the increase. This not only loads the already overburdened healthcare systems but also lowers human productivity especially in low- and middle-income countries. Media reports and published reports have revealed several food safety issues emanating from the food value chain. Consumers today are constantly exposed to food-related hazards such as pesticide residues, mycotoxins, food pathogens, heavy metals, food additives, adulterated foods such as alcoholic beverages and dairy products among others. Food safety has been compromised at almost all levels of the food value chain including the household and institutional level but also the hospitality industry. However, evidence-based research is lacking to guide policies and action points. There is limited information on risk and exposure assessment of food hazards. Putting in place preventive measures as well as policies, regulations and their enforcement by governments can achieve a substantial reduction in the risks. This book presents current research findings addressing areas of concern in food safety for consumer health. The information is useful to scholars and scientists, environmentalists, agriculturalists, the food and hospitality industry, nutritionists and public health specialists, NGOs, distributors, traders, consumer organizations, policy makers, food legislators, civil society and other key players in the food chain.

CHAPTER ONE

BANANA RIPENING IN KENYA: SOME FOOD SAFETY CONCERNS

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Abstract

Fruit consumption has been associated with limiting the harmful effects of diseases such as obesity, diabetes, cardiovascular and cancer. Fruits supply vitamins, sugars, minerals, protein, cellulose, fiber, water, and various phytochemicals that protect the human body against various disorders. However, the nutritional value of fruits is threatened by some malpractices in hastening their ripening. This study presents a systematic review of studies on banana ripening methods in Kenya to develop awareness among the farmers, traders, consumers, scientists and policy makers of the potential health hazards resulting from the use of artificial chemicals in the process. To obtain literature on banana ripening methods, a Google Scholar search engine was used. The focus was given to potential compromise on the nutritional value of banana resulting from applications of selected ripening substances. The reviewed literature indicated that whereas several substances including; apple, acetylene, ethylene, smoke, and ethanol are applied in ripening bananas, calcium carbide is the most commonly used agent. Treated bananas have a uniform and attractive yellow colour when ripe. The consumption of bananas ripened using calcium carbide was associated with health problems such as headache, dizziness, mood disturbances, sleepiness, mental confusion, memory loss, cerebral edema seizures and prolonged hypoxia. Although the use of artificial chemicals in banana ripening attains cosmetic qualities for marketability, the compromise on nutritional value calls for a concerted action by all stakeholders.

Keywords: Consumers, farmers, fruits, Kenya, ripening substances, traders.

Background

Fruits are increasingly being included in the human diet. Factors accounting for heightened consumption of fruits include health concerns, change in consumption patterns where people are diversifying their diets beyond staples, increase in urban dwellers, high disposable incomes, and increased literacy [1]– [5]. Fruits supply vitamins, sugars, minerals, protein, cellulose, fiber, water, and various phytochemicals that protect the human body against various disorders [6], [3]. As such the consumption of fruits has the potential to minimize the occurrence and impede progression of obesity, stroke, Alzheimers, diabetes, cancer, and cardiovascular diseases [4], [7], [5]. Bananas are among the most important global food commodity after rice, wheat and maize [8]– [10]. Nutritionally, bananas are a source of vitamins A, B, and C, provide potassium, magnesium, fiber, are low in fat and sodium, and are cholesterol-free [11]– [13]. The nutritional features of bananas appeal to health-conscious consumers [12]. In Kenya, banana is the most popular fruit [1], [14], [15]. Banana has a market share of 35.6% followed by pineapples (20%), mangoes (17%), avocados (6%), pawpaws (6%), passion fruits (3.6%), oranges (3%), watermelons (3%), and tangerines (2%) [15]. Besides, there is an unmet demand for bananas in the country [16], [17].

In an attempt to meet the demand and maximize profits derived from fruit sales, traders seek to reduce wastage, hasten the process of ripening and attain uniform ripening and an attractive peel colour [3], [13], [18], [19]. Transporting bananas to sales points while green minimizes fruit damage [13], [16], [17]. Therefore, banana traders in Kenya mainly ripen bananas within their sales locale [16].

The purchase of ripe bananas is influenced by the peel colour [3], [16], [19], [20]. Rather than ripen bananas naturally which is a slow process and does not mainly attain a uniform change in peel colour, traders use artificial ripeners [13], [21], [22]. Nevertheless, the nutritional value of bananas is compromised by some malpractices which use artificial ripening chemicals [3], [6], [23]. The theme of artificial fruit ripening has attracted attention among researchers [3], [9], [13], [18], [19], [21], [23]– [29]. A number of studies have been conducted in countries such as; India [25], [26], Pakistan [25], Bangladesh; [19], [23], [25] Nepal; [25, 30] Sri Lanka [18], and Nigeria [29, 21]. In Kenya, documented banana ripening practices are mainly found in newspaper reports [22], [30]– [32]. Although newspaper reports may not be authenticated, such stories indicate that there is usage of harmful ripening chemicals and the consumption of such fruits in the country. Empirical studies that have addressed the subject of banana ripening do so as a sub-theme of other topics [16], [17]. For instance, the main theme of Mbuthia, Kayi and Wambugu [17] is constraints and opportunities along the banana value chain. There is, thus, a dire need for empirical research whose chief theme is banana ripening. This study presents a systematic review of studies on fruit ripening practices, with emphasis on bananas. It is hoped that this review will form a fundamental basis for empirical research on banana ripening in Kenya. The study also aims at creating awareness among the stakeholders in the banana value chain, the farmers, traders, consumers, scientists and policy makers on the potential health hazards resulting from the use of artificial chemicals in the ripening process. After all, people consume chemically ripened fruits due to ignorance [25].

Materials and methods

This study involved a review of both published and unpublished literature on fruit ripening with emphasis on bananas. A literature search was carried out on banana ripening methods, effects of ripening agents on the cosmetic and nutritional quality of bananas, and the policies governing the use of chemicals in banana ripening. To obtain local and international studies on banana ripening, the Google Scholar search engine was mainly used.

Results and discussion

Research indicates that natural ripening, where ethylene inherent in banana fruit induces the process, is slow (taking up to 14 days) and change in peel colour is dull and not uniform (Table 1-1). The period to ripen and change peel colour depends on the method of ripening and maturity of bananas [17], [20]. For instance, Berhe et al. [20] found that farmers in Ethiopia ripened bananas in open wooden boxes leading to a change of colour to black. In an attempt to improve the peel colour, farmers arranged banana hands in layers separated with green grass in holes for 5 days. The peel, however, remained green in colour [20]. To attain the yellow colour upon ripening, farmers kept the fruits above the ground under shade in sacks and crates covered with hay, dry banana leaves and sometimes plastic sheeting for 5 to 6 days [20]. Mbuthia, Kayi and Wambugu [17] observed that farmers in Meru County in Kenya sold their bananas when mature (green and plump). Generally, the more mature bananas are, the shorter the time taken to ripen. The long time taken for bananas to ripen in a natural process implies that traders are not able to supply the demand on time. Besides, the sales are further compromised by either the non-uniform dull pale yellow or black peel colour that makes bananas unattractive to buyers. Furthermore, the dullness of ripe bananas becomes a point of the bargain for lower prices for buyers.

Table 1-1: Effects of ripening agents on time taken to ripen, organoleptic and nutritional quality of fruits

Author	Spatial Unit	Fruit Type	Ripening Agent	Effects	
				Days to Ripen	Organoleptic and Nutritional Attributes
Mbuthia, Kayi and Wambugu 2018	Kenya	Banana	Avocado and Passion	At least 8	Non-homogenous yellow colour; rotting
Berhe et al. 2008	Ethiopia	Banana	Natural in wooden boxes (inbuilt ethylene)	More than 5	Black colour
			Natural in holes cushioned with green grass (inbuilt ethylene)	5	Green colour
Singal, Kumud and Thakral 2012	India	Banana (a bunch of 6 bananas)	CaC_2		
			1g	5	Soft and good peel colour
			2g	4	Poor in flavour
			Apple (1 fruit)	3	Soft and good peel colour
			Natural (control)	10	
Mebratie et al. 2015		Banana	Smoke	8	
			Ethephon	10	Good yellow peel colour
			Low density polyethylene plastic	13	Dull yellow colour
			Teff straw and banana leaf (control)	14	
Siddiqui and Dhua 2010	India Pakistan	Banana	CaC_2	1 to 2	Uniform yellow peel; overly soft; less tasty

	Bangladesh Nepal				
Adeyemi, Bawa, and Muktar 2018	Kaduna in Nigeria	Mango Banana Pawpaw	CaC_2 (10g/kg) Natural (control)	2 for all fruits 7 (mangoes) 5 (bananas) 6 (pawpaw)	Increase in ash, fibre, lipid; decrease in moisture, vitamin, protein, carbohydrates
Nura, Dandago, and Wali 2018	Nigeria	Banana	CaC_2		Yellow peel and dark green stem Moisture, ash, lipid increased with increase in concentration of CaC_2; protein, fibre, carbohydrate, concentration of vitamin C, tritrable acidity and PH decreased with increase in CaC_2 concentration
Du et al. 2016		Banana	Ethylene under high temperature (20^o and 30^{o}c)		91 out of 413 proteins changed significantly
Pokhrel 2013	Nepal	Banana	Smoke Ethylene Fresh rice straw Other fruits		Good yellow peel colour
Amarakoon, Illeperuma,	Sri Lanka	Willard and Velleicolomban	CaC_2 1g/kg		Decrease in taste, balance in sweetness and sourness,

and Sarananda 1999		Mangoes	5g /kg 10g/kg		acceptability with increase in amount of chemical; increase in off odour development; non-significant effect on aroma No significant difference in total soluble solids and titratable acidity between the treated and naturally ripened mangoes
Ashraf-Ur-Rahman, Chowdhury, and Alam 2008	Bangladesh	Mango	CaC_2 Ethylene		Soft, good peel colour Poor in flavour

SOURCE. —Synthesis from Reviewed Literature

Climacteric fruits and artificial chemicals are used as ripening substances (Table 1-1). As shown in Table 1-1, the use of different climacteric fruits as ripening substances had varied results (non-uniform and uniform yellow) of the peel colour. The differences in peel colour may be explained by the type of fruit used and method or environment of ripening. As Mbuthia [16] observed farmers and traders in Meru County in Kenya wrapped bananas plus passions and avocados in polythene bags for 3 to 4 days after which they were removed to allow ripening. However, the banana fingers attained non-homogenous yellow peel colour and began rotting at the tips [17]. Traders alleged that the rotting of bananas was because farmers applied artificial fertilizers in production. However, the rotting may also be due to lack of an ambient environment because the respondents noted that the problem was prominent in July and August, colder months of the year in Kenyan highlands. The use of an apple as a ripening substance led to the attainment of good peel colour in a few days (Table 1). The attainment of a good peel colour may partly be explained in that an ambient environment was ensured in the experiment [26].

Passions, avocados and apples initiate the ripening procedure of bananas from the natural ethylene inbuilt in them. Thus, they do not alter the nutritional qualities of bananas. However, some conditions must be met for good results [34]. Temperature, relative humidity, the concentration of CO_2 and adequate air circulation need to be considered during the ripening process [34]. According to Pokhrel, 1 ripe fruit placed among 20 unripe ones initiated ripening in an open environment compared to 1:100 in a closed one [34]. Other climacteric fruits that may be used as ripening substances include; mango, jackfruit, apricot, peach, plum, tomato, and litchis [19], [26].

Results indicate that artificial ripening chemicals shorten the time taken by fruit to ripen (Table 1-1). As shown in Table 1, the days taken for a fruit to ripen varies with the chemical type and amount used. The use of CaC_2 for example, causes banana to ripen within a short time (2 days) from as many as 14 days (Table 1-1). Apart from CaC_2, ethephon and smoke (Table 1), other artificial chemicals commonly used to induce fruit ripening include ethylene (C_2H_4), methyl jasmonate, ethylene glycol, and ethereal [21].

Several studies on artificial fruit ripening practices are geared towards addressing the marketing concerns—reducing days to ripen and attaining an eye-catching peel colour, and not the safety issues for consumers [18], [25], [26], [28], [29]. Such studies mainly focus on the effects of artificial ripening chemicals on organoleptic attributes and the duration it takes to ripen fruits. Research indicates that the duration of ripening can be reduced further by increasing the amount of CaC_2 [26].

Artificial ripening chemicals have varied effects on organoleptic attributes of fruits (Table 1-1). The application of CaC_2 and ethephon in banana ripening culminates in a uniform bright yellow peel colour that is eye-catching but the stem is dark green (Table 1-1). Also, bananas are overly soft and less tasty (Table 1-1).

Studies that have analyzed the effects of artificial ripening substances on the nutritional attributes of bananas reveal that the use of CaC_2 interferes with the nutritional quality of the fruit (Table 1-1). As shown in Table 1-1, the concentration of banana nutrients decreases with an increase in the quantity of CaC_2 used. Furthermore, CaC_2 has carcinogenic properties (arsenic and phosphorus) [25]. The perils of calcium carbide are amplified if the chemical comes into contact with the fruit because phosphorous hydride and arsenic hydride are fat-soluble, and may dissolve in the wax layer of fruits [18].

In the presence of moisture, CaC_2 reacts to produce acetylene ($CaC_2 + 2H_2O = Ca(OH)_2 + C_2H_2$) [19]. As such acetylene initiates the ripening process but it contains phosphine and arsine up to 95 and 3 ppm, respectively [19]. When the concentration of acetylene is above 10%, it is poisonous to humans [19], [25]. It reduces oxygen supply to the brain, causes headaches, vertigo, dizziness, delirium, seizure and even coma [3], [19]. Vomiting, diarrhoea, burning sensation of the chest and abdomen, thirst, weakness are the early symptoms of arsenic or phosphorus poisoning in humans [19], [34]. Arsenic, phosphorous and acetylene gas may affect the different body organs and cause various health problems like headache, dizziness, mood disturbances, sleepiness, mental confusion, memory loss, cerebral edema, seizures, prolonged hypoxia, and miscarriage [6].

Despite the much-documented potential health hazards of using CaC_2 as a ripening agent and its ban in many countries (Table 2), the chemical is widely used in developing countries [3], [18], [25], [26], [35]. The widespread use of CaC_2 is spurred by the fact that it is cheap, readily available, easy to apply, shortens the time to ripen, gives a uniform ripening colour even in immature fruits, increases shelf life and maintains the ripened colour [3], [6], [19], [24]–[26]. While the foregoing characteristics of CaC_2 appeal to traders, its use raises concern given that there is no specific legislation on fruit ripening in Kenya [35], [36].

The lack of legislation on fruit ripening coupled with the dominance of banana trade within the Kenyan market [16] may prompt unscrupulous traders to use dangerous chemicals. Participation in international food trade prompts the importing countries to put conditions for exporting nations (Table 1-2). For a country to trade in food internationally, she must observe properly stipulated safety standards, regulations related to traceability, product certification, environmental standards among others [36]–[38].

Some artificial ripening chemicals are permitted in some countries (Table 2-2). In developed nations (e.g. the United States of America), the use of non-toxic ethylene is permitted for ripening fruits such as bananas and kiwifruit [24], [35]. According to Islam et al [35], very low concentrations (10 to 50 μL L− 1) of ethylene are sufficient to ripen bananas in non-commercial cases. However, the concentration may increase up to 1000 μL L−1 in commercial practice [35]. Bananas should be exposed to ethylene for 24 to 48 hours within temperatures of between 14 and 18^{o}C, 90-95% RH (relative humidity), and 1% CO_2 [25], [35]. The use of non-toxic ethylene is confined to developed countries partly because the use of the chemical on a commercial basis is expensive [18], [24]. Furthermore, there are sealed chambers or rooms with controlled temperature and relative humidity where ethylene is released to ripen bananas [13].

Table 1-2: Artificial fruit ripening chemicals legislation in selected countries

Legislation	Country
Use of any poisonous chemical such as CaC_2 is prohibited	Bangladesh, Afghanistan, India, Nepal, Pakistan, Sri Lanka
Importation of fruits ripened using artificial chemicals is prohibited	Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia, The United Arab Emirates
Use of ethylene is permitted	India, United Kingdom, United States of America
Use of ethephon in a range of 100 to 200 ppm is permitted	India
No regulation on use of artificial ripening agents	Kenya, Nigeria

Source: Synthesis from Reviewed Literature

Conclusion

Apart from either ripening banana naturally or using climacteric fruits in the process, farmers and traders in Kenya just like in many other developing countries may be using CaC_2. This is because it attains cosmetic qualities for marketability. After all, there is no specific regulation on the use of artificial fruit ripening agents in Kenya. Likewise, banana consumers in Kenya may be eating CaC_2 ripened fruits given that the buying behaviour is mainly influenced by the attractiveness of the peel.

Recommendations

The study recommends the use of climacteric fruits as ripening substances because with ensuring an ambient environment, such agents can attain similar cosmetic qualities as artificial chemicals. Besides, unlike chemical ripening agents, climacteric fruits are not harmful to human health.

A sensitization campaign to all the stakeholders in the banana value chain including; farmers, traders, consumers, scientists, and policy makers, on the potential dangers of using ripening chemicals is recommended. Farmers and traders should be more careful in chemical use in the ripening of bananas. The government should come up with standard fruit ripening techniques. The concerned food safety authorities should devise an effective action plan to check malpractices in accelerating banana ripening. Consumers should become keen on choosing quality. Buying of uniformly bright yellow bananas has high chances that artificial chemicals have been used to ripen them.

This article is based on secondary information. An empirical study to determine the facts as they are in the field is recommended.

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CHAPTER TWO

UNDERSTANDING THE LIVELIHOOD CHALLENGES OF FOOD VENDORS IN THREE MARKETS IN SELECTED INFORMAL SETTLEMENTS IN NAIROBI COUNTY: A CRISIS OR OPPORTUNITY?

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Abstract

Proper urban planning of urban spaces in many informal settlements in Africa continues to present challenges especially among the socio-economically disadvantaged residents. In particular, food vendors in informal markets face many livelihood risks attributable to the legal, physical and socio-cultural environment in which they work. This is despite their important role in ensuring food safety through the chain of storage, processing, production, preparation and retailing. With urbanization, the number of food vendors and consumers in informal markets is on the rise, and hence their challenges need attention by the relevant authorities and in particular the county governments. The study objective was to assess the level of practice of food safety among the food vendors in Githurai, Kibera and Kayole informal markets. The study embraced a cross-sectional survey design. A sample of 500 photographs was taken in Githurai (n=168), Kibera (n=166) and Kayole (n=166). From these, themes and sub-themes were drawn and a discussion generated. Urban agriculture was practiced with vegetables grown using sewer water. In most vendor shops popularly known as "kiosks" or "kibanda", we found that food vendors still embraced the traditional processing methods used in food preparation, food was stored and handled under elevated temperatures and poor personal hygiene practiced by food handlers. Study findings show that there was insufficient amount of knowledge regarding the importance of the safety of food. Findings confirm that the market environment represents an important site for the spread of pathogens responsible for foodborne diseases. Targeted training on safe food handling and provision of infrastructural support (markets) by the Nairobi County government is recommended. Additionally, the use of financial assets available at the national and county level and formation of self-help or support groups for food vendors can be explored as opportunities for mitigation.

Keywords: Livelihoods, retail food safety, food vendors, informal settlements, consumers

Background

Kenya and many other developing countries in Sub Sahara Africa are urbanizing at an unprecedented rate. In Africa, the figure of the growing urban populace is expected to rise to 43% in 2020 from 39% in 2010 [1]. These populace livelihoods are characterized by high unemployment rates, poor housing and provision of social amenities such as security, education and health [2].

Seventy-two percent of residents in Sub Saharan Africa live in informal settlements where they are subject to poor environmental and health conditions, limited livelihood opportunities, and a higher prevalence of other health hazards including poor environmental sanitation and HIV/ AIDS. In Kenya, for instance, sixty to eighty percent of the urban population lives in informal settlements [3]. This, in addition, to increase in the cost of living evidenced by rising food and fuel prices, places the urban households in these informal settlements in a precarious position [4]. The street foods found in these settlements become important because they meet the food and nutritional requirements at affordable prices for the urban poor in the informal settlements [5]. There is also great deprivation as shown from the indicators of non-monetary wellbeing.

Additionally, proper urban planning of urban spaces in many informal settlements in Africa continues to present challenges, especially among the socio-economically disadvantaged residents. In particular, food vendors in informal markets face many livelihood risks attributable to the legal, physical and socio-cultural environment in which they work. Other shocks and stresses related to chronic poverty and political instability affect urban poor households [6]. This is despite their important role in ensuring food safety through the chain of storage, processing, production, preparation and retailing. With urbanization, the number of food vendors and consumers in informal markets is on the rise, and hence their challenges need attention by the relevant authorities and in particular the county government.

Lack of food safety in many informal settlements has contributed to foodborne diseases mainly because of the consumption of contaminated foods in addition to long and broad value chains. The growing trend has been in agro-industrial production with no tangible evidence in food safety and disease control at the retail level. In Kenya, evidence on effective, sustainable and scalable interventions with a focus on improved food safety in domestic local markets is limited. What is notable however is that food safety training of informal value chain actors who benefit from business opportunities after training has been successful [7].

There is a dearth in knowledge on the safety of street foods consumed in Kenya. This study aimed to investigate the safety of street food sold in informal settlements from the food vendors' point of view by understanding the opportunities and challenges in handling these street foods.

Methodology

Nairobi County was purposively selected since it has the majority of the urban informal markets. The Githurai, Kibera and Kayole informal markets were randomly selected. The study embraced a cross-sectional survey design. Systematic sampling was done by category of the food value chain: production, processing, marketing and preparation/ consumption. A sample of 500 photographs was taken in Githurai (168), Kibera (166) and Kayole (166). From these, themes and sub-themes were drawn and a discussion generated using qualitative approaches. Photography was used to collect information on the practice of food safety among food vendors in the sampled markets. It was also used to document the livelihood risks attributed to the legal, physical and socio-cultural environment in the informal markets.

Results

Socio-economic and demographic characteristics of the food vendors

The study observes that the street food industry is growing rapidly. The urban poor youth, women and men working outside their homes appreciate it as an affordable source of food for their nutritional needs. It is also a source of livelihoods for many in such setups who have not had an opportunity to have gainful employment opportunities. Hence, street vending is a major employer for both genders and across the ages.

Food safety of street vended foods

Recent studies [8-10], show that more than seventy percent of street foods tested positive for pathogenic microorganisms. These microorganisms included *Klebsiella pneumoniae, Enterobacteriaceae, Clostridium perfringens, Staphylococcus aureas, Bacillus aureas, salmonella, shigella, Entamoeba histolytica.* The general observation was that food safety practices were not adhered to. Some of the food preparation kitchens were established in unhygienic places next to sewer lines or next to the roads. The foods were stored under poor conditions. For instance, salads were stored in plastic containers that were visibly not clean. Hot foods from cooking were also placed in plastic containers and not covered. Furthermore, storage of the vegetables, prepared fruits and tubers were done in plastic bags. During the processing of these foods, the domestic animals including ducks and goats, and insects like houseflies came into contact with the foods. This was due to the placement of the foods on the ground and the location of the vibandas. Foods that the animals and houseflies came into contact with were not discarded. Most of these animals and insects passed through wastewater or open sewerage and hence transferred microorganisms from their bodies to the food that they came into contact with.

Availability and accessibility of infrastructure for ensuring food safety

The street vendors lacked basic food, personal and environmental hygiene. All the markets sampled lacked basic social amenities to include safe clean water, toilets with running water, shelters and storage facilities. Vegetables and fruits were sold when they were overripe or rotten, on the floor or near the roadside where they were exposed to contamination from dust, houseflies, sewerage. There were no appropriate storage facilities like refrigerators, coolers or safe food containers. There was also the risk of cross-contamination as the vegetables and fruits were sold next to meats such as fish, pork and offal.

The vendors confirmed that the source of many of the vegetables and herbs were nearby farms that were irrigated using sewerage water. This was especially the case for Githurai. The use of sewerage water for irrigation increases the risk of microbial contamination of the vegetables and herbs planted under these conditions.

Discussions

British Department for International Development Sustainable Livelihood Approach and its framework

The British Department for International Development (DFID) developed the Sustainable Livelihood Approach (SLA) and its framework to be used in development practice. Sustainable livelihoods form the basis of SLA. The core principles of SLA and its framework are people-centered, holistic, dynamic, building on strengths, macro-micro links and sustainability. The framework seeks to conceptualize how people operate within a vulnerability context under the influence of economic shocks, long term trends and seasonal constraints. It also goes ahead to conceptualize how they draw on different types of livelihood assets or capitals in different combinations that are affected by the vulnerability context, a range of institutions and processes and how they use their assets to develop a range of livelihood strategies to achieve desired livelihood outcomes. The elements of the framework include vulnerability context; livelihood assets; policies, institutions and processes; livelihood strategies; and livelihood outcomes [11].

External shocks and stressors

The livelihoods of the street vendors in the informal markets are prone to shocks and stressors as evidenced by their environment and practices. These shocks and stressors increase the vulnerability of not only their livelihoods but the community at large to foodborne illnesses and other health conditions caused by poor handling and storage conditions of the foods. The handling of the foods in unhygienic conditions increases the chances of contamination of the foods with coliform bacteria like *Escherichia coli* and other pathogenic bacteria. The ripple effect of this threat is, among others, increased disease incidence, lost hours/ days of production when bedridden and increased spending in health care for the consumers of the food products. The cumulative effect of all these is the reduction in the livelihood outcomes.

The street vendors also offend the law due to poor handling of the human food they trade in. The food handling regulations of the county and national government stipulate the conditions for handling food and the requirements for one to put up a food vending point or service area. Among these laws are the Food, Drugs and Substances Act, Chapter 254; the Meat Control Act, Chapter 316; and the Public Health Act, Chapter 242 [12]. The main officers tasked with the inspection of the premises to check on compliance are the public health officers and any other personnel tasked to do the same by the county government. The structures and processes that are in existence are prohibitive towards the working environment and practices of the livelihoods of the street vendors. The structures and operating environment of most of the street vendors do not meet the recommendations established by these laws. All these legal hurdles notwithstanding, the framework put in place by the government is for the benefit of both the street vendor and the consumers.

Livelihood assets

The street vendors own vending assets. These assets include containers, cooking equipment, food storage containers and units, food stands and shades. The assets are inefficient, inappropriate or not sufficient to achieve food safety. For instance, street vendors have food containers to keep the food after cooking. However, the materials and physical attributes of the containers are not up to the recommended standards for the specific foods, temperature or use. Some of the street vendors were using plastic containers meant for draining cold water from vegetables to drain oil from deep-fried bhajias. That poses a risk to the consumers. They have the right food handling equipment for one purpose but improvising it for a different purpose. This may be one of their coping strategies. The street vendors have premises used for cooking which still serve as eating space for customers. The quality of the building structures was not up to the standards that would ensure food safety as per the laws. To mitigate this, teaming up of the vendors and pulling resources together can help buy enough good quality building resources and hire labor for the construction. Alternatively, the application for loans and grants can help bridge the financial gap hindering access to the required materials and skills.

Transformative structures and processes

Transformative structures and processes at the county level were lacking. This was shown by the poor social amenities and basic hygiene and sanitation infrastructure. The open sewerage and blocked drainage systems increased the chances of bacterial contamination of the food either with direct contact with the wastewater or through vectors. Proper drainage systems and timely repair of blocked sewerage and drainage systems would ensure that the exposure of the foods to the wastewater is kept to the minimum. Additionally, water is a very key aspect of hygiene and sanitation in the workplace. It is, hence, very important to ensure that there is a constant supply of clean and safe water to these markets. Thus it would be vital to seek consultation with the authorities in charge of the water and sewerage systems and chat a solution to the problem of water and sewerage system.

Conclusion and Recommendations

Markets in informal settlements represent a significant avenue for the spread of foodborne diseases. The county governments should provide guidelines and the necessary training to street food vendors and ensure food safety training requirements before issuing licenses to any street food vendor. Social amenities and efficient storage facilities for foods must be provided. The provision of infrastructural support by the Nairobi County government will help vendors maintain food hygiene standards. Local authorities may consider the informal food sector as partners in local development initiatives by legalizing street foods sale and implement policies and programmes aimed at creating adequate conditions for the informal food sector while minimizing health risks. The government can also come up with standards for use during the sourcing of foods, packaging and marketing of food and safety and quality of street foods.

The main focus of the training should be the street vendors themselves and hence the programming of the training should be as practical and simplified as possible. Training the vendors on jargon and technical concepts may not be very effective.

Improved safety of food sold can be achieved through awareness-raising programmes involving several partners such as the Food Vendors Women Groups and other Associations, Local County Government, Ministry of Health, Consumer Organizations and Not for Profit Organizations in the areas.

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Conflict of Interest

The authors declare no conflicts of interest.

Ethical Considerations

All sampled food vendors were approached and consent for participation in the survey was sought. The food vendors who consented signed a prewritten consent form.

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Pictorial representation

1. Poorly built makeshift kitchens

2. Dirty food used for preparing salads

3. Poor food storage

4. Plastic bags used for packaging food

5. Food preparation in the open air

6. Animals coming into contact with food

7. Vegetables irrigated by raw sewer water

8. Food sold next to sewers

9. Sale of rotting food

CHAPTER THREE

FOOD SAFETY RELATED KNOWLEDGE, ATTITUDE AND PRACTICES AMONG FOOD MARKETERS AND TRADERS IN NAIROBI CITY'S INFORMAL SETTLEMENTS, KENYA

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Abstract

Urbanization, increasing population pressures and lifestyle changes continue to affect food access. Informal settlements are characterized by overpopulation, low incomes and underdeveloped infrastructure. Most residents lack post-secondary education. Nutrition education interventions have shown a positive relationship between knowledge and practices. However, knowledge alone is not adequate to improve food safety practices. The main objective was to establish food safety-related knowledge, attitude and practices among food traders in Nairobi City's informal settlements, Kenya. A cross-sectional survey design was adopted among 204 randomly selected respondent food marketers/ traders selected from three randomly sampled informal settlements in Nairobi city. A structured questionnaire was used to collect data. Descriptive and inferential statistics were used at a significance of $p<0.05$. Written informed consent was sought from the respondents. 67.2% of the respondent traders were females with a mean age of 34.8±1.29 years. About 68.6% of them were married while 30.4% and 54.4% had primary and secondary education respectively. About 87.7%, 88.7% and 97.5% owned radio, TV and phones respectively. Only 12.7% had received training on food safety in the last 6 months mainly from a health worker. Half of them (46.6%) had never heard of aflatoxin and related effects. 31.4% knew the main cause of aflatoxin in cereals was excess moisture and incomplete drying. 42.2% knew that cereals infested by aflatoxin molds were unfit for human consumption. 50.5% knew at least ≥2 food practices that make food unsafe while 19.6%, 36.8%, 16.7%, 18.6% and 34.8% knew other traders who sold, artificially ripened fruits, vegetables grown from sewage water, vegetables with chemical residue, who mixed bad/ rotten and good cereals to reduce cost and added chemicals to milk to make it last longer respectively. 36.3% were bothered that they could be selling unsafe food to their customers. Only 54.4% had access to food storage facilities. 96.1% and 98.0% had reliable water access and functional toilets in the market respectively. There was a need for training in food safety accompanied by correct messaging among middle-men and marketers/ traders. Improvement of infrastructure is recommended.

Key words: urban, food safety, knowledge, practices marketers/ traders, Kenya.

Background

Urbanization, increasing population pressures and lifestyle changes continue to affect food access. Education literacy levels and food safety and nutrition knowledge among food marketers and traders affect the practices of urban food traders in informal settlements. Inadequate access to financial and extension services, high unemployment rate, especially among youth, inadequate market infrastructure, and a variety of cultural values combine to determine the food safety related practices among such food traders [1]. Food traders in informal settlements, otherwise known as vendors are people who offer food commodities, cooked or raw, for sale to the public without having any permanent built-up structure from which to sell from. These serve a significant part of urban food consumption for most consumers in informal settlements in urban centers and urban areas daily [2]. Food is a silent vehicle for microbial, chemical and physical hazards [3]. There is evidence on the potential for the contamination of street foods with pathogenic micro-organisms and related disease outbreaks traced to consumption of contaminated food [4]. Nutrition education interventions have shown that knowledge can influence practice except in situations where knowledge alone is not adequate and where the environment does not support the correct practices [3]. While food marketers and traders' main objective is profit and proceeds from the sale of such food, food safety aspects cannot be ignored as improper practices can lead to loses and client/ customer mistrust. Here remains a research gap on the food safety knowledge, attitude and practices among food traders in informal markets [5]. The objective of this study was to establish the food safety related knowledge, attitude and practices among food marketers and traders in Nairobi City's informal settlements, Kenya.

Methods

A cross-sectional survey design was adopted among 204 respondent food marketers/ traders randomly selected from three informal setups in Nairobi city to establish and understand the food safety related knowledge, attitude and practices (KAP) among the food traders and the general population. Three informal settlements were randomly selected. Respondents were also randomly sampled, from Kibera informal settlement n=54, 26.5%, Githurai n=75, 36.8%, and Kayole n=75, 36.8%. Both male and female food traders were included in the study. The main data collection tool was a structured questionnaire. Research assistants who knew the study sites helped collect the required data. An observation checklist was also used to collect data whose findings are reported elsewhere. Data were analyzed using inferential and descriptive statistics at $p<0.05$. Written informed consent was sought from the respondents and confidentiality assured.

Results

Food marketers/ traders demographic and socio-economic characteristic

This study targeted respondents whose main occupation was food marketing/ trading at Nairobi's informal settlements and therefore occupation is not a reported variable in this section. Most of the respondents (67.2%) were female while the mean age was 34.8±1.29. About 68.2% were married while only half had secondary education. Over 80% of them owned communication gadgets that can be used to communicate food safety messages. These included mobile phones, radio and TV (Table 3-1). Only 27.9% of them owned refrigerators.

Food safety knowledge among food marketers/ traders in Nairobi City informal settlements

Overall knowledge of food safety was poor with only 12.7% reporting to have received training on food safety in the last 6 months to data collection. Table 3-2 shows the source of food safety-related knowledge received by the traders 6 months to data collection. Close to half of them (46.6%) had heard about aflatoxins and related effects. There was no association between age or gender and knowledge about aflatoxins (Pearson's R, $p>0.05$). There was, however, a positive association between education and knowledge about aflatoxins (Pearson's R, $p=0.029$). About 31.4% knew the main cause of aflatoxin in cereals was excess moisture and incomplete drying. 42.2% knew that cereals infested by aflatoxin molds were unfit for human consumption.

Table 3-1: Food marketers/ traders demographic and socio-economic characteristics

Food marketers/ traders demographic and socio-economic characteristic	N=204	
	N	%
Sex		
Male	67	32.8
Female	137	67.2
Age (years),		
Mean	34.8±1.29	
18 - 35 years	116	56.9
36 - 49 years	68	33.3
50 - 59 years	16	7.8
60 and above years	4	2.0
Marital Status		
Single	54	26.5
Married	140	68.6
Widowed/ divorced	10	4.9
Education		
Primary	62	30.4
Secondary	111	54.4

Vocational	7	3.4
College/ university	24	11.8
Ownership of Assets		
Radio	179	87.7
TV	181	88.7
Mobile phone	199	97.5
Refrigerator	57	27.9

Over half of them (62.3%) did not know the dangers of consuming food infested with aflatoxin-causing molds while a quarter of them (27.4%) and 9.8% cited stomach/ digestive problems and cancer as the consequences of consuming aflatoxins infested foods respectively. Despite their owning mobile phones, radios and television sets, only one percent reported having received relevant knowledge on media, implying an opportunity that has not been explored. Indeed, while farmer training has been reported, and similarly, training on food preparation to women and caregivers, the food traders seem to be forgotten actors in the food value chain, especially in informal settlements. About 77.9% of the food traders expressed the need or desire for training on food safety. This was irrespective of the food commodities they sold.

When asked about their knowledge of food preservation methods, 63.2% reported knowing at least two or more food preservation methods. The commonly reported methods were packaging (18.6%), refrigeration (57.4%), drying and exposure to open-air (44.1%) and use of chemicals/ pesticides (12.7%), drying (1.5%), fermentation (5.9%) and salting (2.5%). The results show that the study population was not knowledgeable on food preservation methods that otherwise would be considered traditional such as smoking and drying. When asked whether they knew other traders who sold artificially ripened fruits and/ or vegetables that are grown in sewerage water and vegetables with chemical residue, 19.6%, 36.8% and 16.7% respondent in the affirmative respectively. Further, 18.6% reported knowing other food traders who mixed bad or rotten cereals and legumes with good ones to reduce losses while 34.8% reported knowing milk traders who added chemicals and other substances to milk to make it last longer, taste better and appear good. This is not a matter of lack of food safety knowledge but the wrong attitude. More results on attitude are presented in the next section.

Table 3-2: Distribution of respondents by food safety related knowledge

Food marketer/ trader's knowledge aspects	**N=204**	
	N	**%**
Number that received training/ knowledge on food safety in the last 6 months	26	12.7
Source of that training/ knowledge		
Health worker	16	7.8
Parents/ family/ friends	3	1.5
Agricultural extension officer	1	0.5
Electronic media/ TV, Radio	2	1.0
NGO	3	1.5
Other , hotel training	1	0.5
Ever heard of aflatoxin and related effects	**95**	**46.6**
Knows the causes of aflatoxin in cereals as excess moisture, incomplete drying or poor/ wrong storage	64	31.4
Knows that cereals/ foods infested by aflatoxin molds are dangerous to health	86	42.2
Knows at least ≥ 2 food practices that make food unsafe	**103**	**50.5**
Known specific food practices that make food unsafe*		
Not aware/ doesn't know	27	13.2
Agro-chemical residue in food	5	2.5
Artificial ripening of fruits	25	12.3
Use of bad cooking oils e.g. transformer oil	23	11.3
Storage/ wrapping that increases aflatoxin	16	7.8
Presence of heavy metals in food	1	0.5
Stones in food, cereals and pulses	5	2.5
Sewage grown food	12	5.9
Overheating food	3	1.5
Poor sanitation, unclean utensils	5	2.5
Selling, buying expired food	105	51.5

***Multiple responses**

Food marketers'/ traders food safety related attitudes

Table 3-2 presents results related to the respondents' attitudes on food safety. Majority of them were reportedly not aware or bothered that they could be selling unsafe or spoilt food to their customers. A quarter of them (24.5%) were bothered that they could be selling unsafe food to their customers while 12.3% of them extremely bothered. Further, a quarter of them (24.0%) were extremely bothered that someone they knew, another food trader sold unsafe food to customers but reported that there was nothing they could do. There was no association between food trader's age or gender and attitude (Pearson's R, p>0.05).

Table 3-2: Food marketers'/ traders' food safety related attitude

Food safety attitude characteristics	**N=204**	
	n	**%**
Bothered they could be selling unsafe/spoilt food		
I don't sell unsafe or spoilt/ am not aware	130	63.7
Extremely bothered	25	12.3
Somehow bothered	9	4.4
Bothered	16	7.8
Not bothered	24	11.8
Bothered someone they know sells unsafe food		
I do not know anyone/ not aware	64	31.4
Extremely bothered	49	24.0
Somehow bothered	28	13.7
Bothered	54	26.5
Not bothered	9	4.4

Food safety practices among food marketers/ traders in Nairobi City informal settlements

The traders interviewed were mainly small scale with a sole proprietor (71.6%) or of 2-10 people (27.9%). The main food commodities sold by the respondents were milk by 5.4% of respondents, vegetables (24%), fruits (15.2%), both fruits and vegetables (15.2%), cereals (12.3%) and cooked food (26.5%). The rest traded in meat and/ or fish. There was no significant difference between age and food commodities sold by the respondents (X^2, p=0.324). The main source of food merchandise was the market (34.8%) and from middle-men (33.8%) (Table 3-4). About half of the respondents (54.4%) reportedly had access to a food storage facility (mainly hired space) while 52.9% reported having used the facility within 30 days to data collection. When asked how they communicated to their customers about their food merchandise (advertised), 35.8% and 41.7% reportedly mentioned word of mouth and display of wares/ real food respectively with few (4.4%) mentioning repeat customers. There was minimal mention of media, support/ corporative groups, implying poor uptake of technology or group cohesion to enhance trade; yet these are forums that can be used to enhance knowledge on food safety. Table 4 shows more food safety related practices.

Table 3-4: Food safety related practices among food marketers/ traders

Food safety related practices	**N=204**	
	n	**%**
Size of enterprise		
One/ self	146	71.6
2-10	57	27.9
>10	1	0.5
Food marketer/ trader source of food merchandise		
Direct from farmers/ the farm	35	17.2
From farmer cooperatives	7	3.4
Own produce	1	0.5
Middle men	69	33.8
Market, *soko*	71	34.8
Direct from manufacturing company	1	0.5
Cooks and sell food	20	9.8
Main form of transport food stock/ merchandise from source to stall / market		

Human labour	51	25.0
Motor bike/ cars	114	55.9
Lorry	27	13.2
Animal drawn cart, donkey/ wheelbarrow	12	5.9
Food storage facilities		
Access to food storage facility	111	54.4
Last time the facility was used (within 30 days)	108	52.9
Channels of communication to customers		
Social media/ mobile telephone	34	16.7
Print/ newspaper/ electronic TV or radio advertising	0	0.0
Word of mouth	73	35.8
Display of wares/ real food	85	41.7
Reliance on repeat customers and their referrals	9	4.4
Marketing support groups/ cooperatives	0	0.0
Respondents not keen on this aspect	3	1.5

Food safety practices related to water and sanitation

Food safety practices related to water and sanitation were as follows; an impressive 96.1% reported to access water at least three or more times a week mainly from the City Council. About 30.9% and 16.2% reported had running water available or accessed the water from a tank with a tap respectively. The rest reported storing water in containers. This is good as the water was used to wash fruits and vegetables, for drinking, washing hands among other related practices. This study, however, did not test the quality of that water. Nearly all respondents (98%) impressively reported having access to a functional toilet in the market place, most of which was shared (95.6%) (Table 3-5). It was reported that these were communal toilets charged at a fee for every use. The fee went towards maintaining the toilets and ensuring water supply.

Table 3-5: Food safety practices related to water and sanitation

Food safety related practices related to water and sanitation	N=204 n	%
No. of food marketers/ traders with reliable water access ≥3 times/ wk	196	96.1
Storage of that water		
No water	8	3.9
Running water available	63	30.9
Water tank with tap	33	16.2
Water bottles/ small 5-litre containers	30	14.7
≥20-litre water containers	65	31.9
Other containers	5	2.5
No. of food marketers/ traders with functional toilet facilities at market/ work station	200	98.0
Sharing of toilet facilities	195	95.6
Not shared with non-household members	7	3.4
Shared by 2-10 non-household members	39	19.1
Communal toilet facility	154	75.5

Observations showed that the traders were not in any particular clothing such as protective gear such as aprons or headgear. They also did not care about the same. Results showed that there was no relationship between knowledge and practice ($p>0.05$). This could be explained by the fact that various factors, other than knowledge, influenced practice. These included lack of a properly constructed market and lack of running water at the point sale. Other factors included nearness to dusty roads, generally poor conditions in terms of sewerage and refuse disposal. These are the major characteristics of informal settlements in the study area.

Discussion

Food safety is the reasonable certainty that no harm will result from the intended use of food under the anticipated conditions of consumption [6]. Most households in urban areas source their food from the market place. The source of food, if not clean or safe, can introduce microbial and other toxicities to food especially in resource-poor settings where hygiene and sanitation are poor, more so in handling foods consumed raw such as fruits and some vegetables. There are many benefits of acceptable and correct food safety practices [7]. These include lengthening the food's shelflife, saving the food marketer/ trader losses from unsafe food, enhances customer/ consumer trust and confidence and saves both the food marketer/ trader time hence increasing profit margins. Direct consumer-based benefits from purchasing safe food include food commodity usability, nutrient enrichment such as in fortification and fermentation, and good health from consumption of safe food. These benefits may not be realized when the food marketer/ trader lacks the related and necessary knowledge. This study showed a lack of training among food marketers, less knowledge in terms of food safety, processing and preservation methods among other aspects. Only a few of the respondents knew the traditional food preservation methods including smoking and fermentation. There was also no evidence of practicing such methods that not only preserve food but make it safe. Similar findings were reported by [8]. There was no significant association between knowledge and practice.

Food safety concerns are especially important in handling foods such as animal products like meats, milk and fish; and fruits and vegetables consumed raw. Processing and selling food should be done in hygienic conditions and using clean appropriate materials. The study findings showed communal availability of water stored in communal tanks. Toilets were also shared. Practices such as washing hands after visiting the toilet were not established even though this would have shown the relationship between knowledge and practice. This was constrained by the fact that this was a cross-sectional study and did not follow respondents for observations. Challenges to food processing which can be turned into intervention opportunities include lack of or low knowledge/ training, technology uptake and improved markets. This is in agreement with observations by [9]. Aspects of food safety in marketing and trade established in this study included safe transportation of food from the source, processor or distributer to the point of sale. Improved infrastructure, transportation and condition of markets are important. The study showed the use of motorized transport, hand carts and human transport were mainly used to transport food to the point of sale. The food marketers and traders can benefit from improved knowledge on how to transport and handle different foods to enhance food safety, to minimize losses and retain nutrients. The study findings also showed lack of technology maximization not only to improve sales but also to enhance food safety. A good example is the lack of food storage facilities that are technology-friendly. Despite high ownership of telephones and radio, there was minimal reporting on their use for enhancing food safety and advertisement to increase sales.

The food marketers'/ traders' food safety knowledge levels are important as this is likely to influence practice even though correct practices may be hampered by the absence of water and other sanitation facilities. Results from this study show the need to address knowledge and practice gaps and therefore, promotion of socio behavior change communication (SBCC) in food safety among food traders is recommended. The findings showed a severe lack of training not just on food safety but on other related aspects such as food preservation methods, which if utilized, can address food loses and the temptation of the sale of unsafe or expired food [3]. Considering the low literacy levels of the traders, the development and implementation of do-able food safety messages and strategies need to be promoted. This would complement findings by [10]. This may require re-designing and re-packaging existing agricultural production and nutrition messages. Further, due to reading challenges or lack of time to do such, the most appropriate channel of communication such as the use of radio and telephones and appropriate language choice should be adopted [11]. A study conducted in Italy to assess knowledge, attitudes, and practices concerning food safety among formal food handlers found that the majority of food handlers who had attended a training course had the knowledge and a positive attitude toward food disease control and preventive measures [12]. Likely, training food traders in an informal set-up like the sample in this study would yield similar results. Market information such as updated food safety messages, formalization of trading contracts and streamlining relationships with suppliers, middlemen and food retailers to enhance the competitive trading and improvement of market-level gross margins is necessary. Building trust in the marketing processes especially from the distributors to retailers is very important as traders may not need to pass on food safety issues and gaps to the consumers. This would also enhance meeting set standards [9].

Conclusion and Recommendations

Nairobi's informal settlements play host to most of the city's population. It was concluded that the facilitation of training for marketers and traders on food safety and food storage is necessary. The gaps identified show the need to promote effective food safety and nutrition education package especially on food storage and selling of unsafe food. The results showed a positive correlation between education levels and food safety knowledge. Hence it is recommended that school programmes or curriculums strengthen food safety content covered especially up to secondary school level. The food marketers/ traders owned radios and telephones that can be used to enhance knowledge and act as reminders for best practices and behavior change communication. Such means of communication can also help the food marketers/ traders market their food commodities. Formation and strengthening of marketer/ trader-marketer/ trader self-help groups is highly recommended as these are critical entry platforms for stakeholder partnerships and support.

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Conflict of interest

The authors declare no conflict of interest.

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CHAPTER FOUR

PREVALENCE AND CHARACTERIZATION OF *ASPERGILLUS FLAVUS* AND OTHER MOLDS IN FRESH AND DRIED FISH SOLD IN KISII COUNTY, KENYA

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Abstract

Consumption of fish provides a balance of protein, vitamins and minerals. However, fish is sometimes contaminated with fungi that produce aflatoxins. Consumption of aflatoxin-contaminated fish can cause serious negative health implications such as cancer. This study aimed at determining the molds associated with fresh and dried fish sold in Kisii County, Kenya. Samples of fresh and dried *Rastrineobola argentea* (Omena), *Clarius gariepinus* (African catfish), *Lates niloticus* (Nile perch) and *Oreochromis niloticus* L. (Nile Tilapia) were obtained from four markets by systematic random sampling. The moisture content of all samples was determined by oven drying. The prevalence and characterization of *Aspergillus flavus* and other molds were determined through morphological techniques using Sabouraud Dextrose Agar, Czapak Dox Agar, and *Aspergillus flavus* and *parasiticus* agar. Seventeen fungal species namely; *Cunninghamella*, *Rhizopus*, *Penicillium*, *Candida*, *Phoma*, *Trichoderma*, *Aspergillus*, *Mucor*, *Alternaria*, *Fusarium*, *Trichophyton*, *Cladosporium*, *Acremonium*, *Mycosporum*, *Geotricum*, *Scopulariopsis* and *Cladophialophora* were isolated from both fresh and dried fish. *Aspergillus* spp was frequently isolated from fresh *Rastrineobola argentea* (6.3%) from Riosiri, tilapia (13.5%) from Keroka, Nile perch (11.5%) and catfish (11.5%) from Riosiri. For dried fish, *Aspergillus flavus* was frequently isolated from *Rastrineobola argentea* (26.5%) and tilapia (18.3%) from Nyakoe, Nile perch (19.2%) and catfish (28.6%) from Daraja Mbili. The means were compared using the One-Sample T-Test of SPSS version 20. The results indicate that fish sold in Kisii County are contaminated with *Aspergillus flavus* and other molds which could pose a health risk to consumers. It is recommended that frequent monitoring of fish sold for the detection of aflatoxigenic fungi be done.

Keywords: prevalence, *Aspergillus flavus*, molds

Background

Fish supplies a balance of protein, vitamins and minerals. Fish and fish products such as fish fillets, fish balls, fish samosa and fish soup are considered a source of high-quality animal protein that is cheap and easily available both in urban and rural areas for human consumption. In addition, they are exceptionally rich in calcium, phosphorus and supply of ß- complex vitamins [1]–[3]. Interest in fish consumption has increased over the years due to the health benefits it has; being a rich source of omega-3 fatty acids that reduce cholesterol levels and the incidence of heart diseases and pre-term births [4]. However, fish is sometimes contaminated with fungi that produce aflatoxins. Growth of aflatoxigenic fungi such as *A. flavus* and *A. parasiticus* in foodstuffs is a common phenomenon in developing countries such as Kenya.

These fungi are recorded to constitute a public health hazard due to aflatoxin production. The aflatoxins produced cause some degree of acute toxicity when given or consumed in high amounts in addition to being potential carcinogens [6]. These aflatoxigenic fungi can grow in improperly stored foodstuffs even at very low moisture contents of about 11 % and represent a serious source of contamination in foods all over the world [7].

In Kenya, many individuals suffer from diseases associated with lower and chronic levels of aflatoxin consumption in maize, groundnuts and other foods. It has been estimated that more than 5 billion people in developing countries are at risk of chronic exposure to aflatoxins through contaminated foods and feeds [8]. Consumption of aflatoxin-contaminated fish can cause serious negative health implications such as cancer, stunted growth in children, immune suppression and promotion of hepatitis B infection. There is, therefore, a need to determine the prevalence of these aflatoxigenic fungi and their source. This will be important in establishing appropriate mitigation measures.

Materials and methods

Sample collection

Four hundred grams of sun-dried *Rastrineobola argentea* (Omena), *Clarius gariepinus* (African Catfish), *Lates niloticus* (Nile perch) and *Oreochromis niloticus* (Nile Tilapia) fishes were sampled and purchased by the systematic random design from six retailers in four different marketing sites; Keroka, Riosiri, Daraja Mbili and Nyakoe in Kisii County. The samples were packed in sterile polythene bags and tagged accordingly and taken to Kenya Agricultural and Livestock Research Organisation (KALRO) Kisii pathology laboratory for mycological analysis.

Mycological assay

The following mycological assays were carried out on fresh and sun-dried fish samples and fish feeds namely: enumeration of fungal colony-forming units (CFU), isolation and identification of molds which largely involved microscopy. Enumeration was done according to the protocol by Pitt and Hocking [9]. Sun-dried fish samples were ground using a blender and serial diluted. A dilution of 10^{-3} was used during spread plating. The spread plate technique was used in quantifying and detecting molds in the sun-dried fish samples. From the fungal growth on primary cultures, fungal isolates were sub-cultured using a plug that was taken from the periphery of fungal cultures and placed onto fresh media of Sabouraud Dextrose Agar (SDA) to get distinct colonies. The obtained pure isolates were then stored in the dark at 25 ºC until fruiting structures formed for further identification [10]. Czapak Dox agar (CZ) and *Aspergillus flavus* and *parasiticus* agar (AFPA) were used to differentiate the colonies of the aflatoxigenic *Aspergillus flavus* and *Aspergillus parasiticus*. Taxonomic identification of the various molds was carried out according to the macro and microscopic characteristics of the colonies using identification keys [11], [9], [12], [13]. Macroscopic features of *Aspergillus* cultures studied were colony colour both front and reverse, colony diameter, exudates and colony texture. The slide culture method for microscopic features of the isolates was carried out. The features included conidial heads, stipes, conidial colour, vesicle shape and seriation, metula covering, conidia shape and roughness.

Results

Frequency of fungal isolates from fresh fish samples

Fungal isolates were obtained from fresh fish samples that were sold in four different markets namely Keroka, Daraja Mbili, Nyakoe and Riosiri. A total of four hundred and thirteen isolates were obtained from fresh fish samples of *Rastrineobola argentea*, Catfish, Nile perch and tilapia. The isolates comprised of fifteen different fungal species identified as *Cunninghamella*, *Rhizopus*, *Penicillium*, *Candida*, *Phoma glomerata*, *Trichoderma*, *Aspergillus*, *Mucor*, *Trichophyton*, *Alternaria*, *Cladosporium*, *Acremonium*, *Fusarium*, *Mycosporum* and *Geotricum* sp.

Isolates from fresh *R. argentea* in different markets

A total of twenty isolates were obtained from samples of fresh *R. argentea* (Plate 3-1) purchased from Keroka market. This comprised of four different fungal species namely *Cunninghamella*, *Rhizopus*, *Penicillium* and *Candida* spp. From Daraja Mbili market a total of twenty-four isolates were obtained. They comprised of *Penicillium*, *Rhizopus*, *Phome glomerata* and *Candida* spp. Twenty isolates were obtained from Nyakoe market comprising *Rhizopus*, *Trichoderma* and *Penicillium* spp. In Riosiri market, a total of 32 isolates were obtained. They comprised of *Aspergillus*, *Penicillium*, *Cunninghamella*, *Mucor* and *Phome glomerata* (Table 4-1). The molds whose prevalence was significant in fresh fish were *Penicillium* sp (p=0.006) in *R. argentea*, Mucor sp (p=0.020) and *Rhizopus* sp (0.034) in Tilapia (Table 4-1 to Table 4-4). Fish buyers were seen touching fresh *R. argentae* with bare hands (Plate 3-2).

Plate 3-1 Fresh *R. argentea*

Plate 3-2 Fish buyer touching

Table 4-1: Mycoflora of fresh *R. argentea* from different markets in Kisii County

Mold	Keroka (n=20)	Dara Mbili (n=24)	Nyakoe (n=20)	Riosiri (n=32)	P
Cunnighamella spp	10 (50.0 %)	-	-	10 (31.3 %)	-
Rhizopus spp	5 (25.0 %)	8 (33.3 %)	9 (45. 0 %)	-	0.093
Penicillium spp	3 (15.0 %)	6 (25.0 %)	4 (20.0 %)	5 (15.6 %)	0.006
Candida spp	2 (10.0 %)	-	-	-	-
Phome glomerata	-	7 (29.2 %)	-	9 (28.1 %)	0.995
Yeast spp	-	3 (12.5 %)	-	-	-
Trichodema spp	-	-	7 (35.0 %)	-	-
Aspergillus spp	-	-	-	2 (6.3 %)	-
Mucor spp	-	-	-	6 (18.7 %)	-

Thirty-seven isolates were obtained from fresh tilapia from Keroka, thirty from Daraja Mbili, fourteen from Nyakoe and forty-eight from Riosiri market. The different fungal isolates obtained and their percentage prevalence is as shown in Table 2. Isolates and fungal species from fresh Nile perch and catfish were as shown in Tables 3 and 4 respectively.

Table 4-2: Mycoflora of fresh tilapia from different markets in Kisii County

Mold	Keroka (n=37)	Daraja Mbili (n=30)	Nyakoe (n=14)	Riosiri (n=48)	P
Aspergillus (spp)	5(13.5%)	4(13.3 %)	-	3(6.2 %)	0.074
Trichoderma spp	10(27.1%)	-	-	8(16.7 %)	1.000
Penicillium spp	9 (24.3%)	6(20.0 %)	5(35.7 %)	-	0.109
Rhizopus spp	13(35.1%)	8(26.7 %)	-	15(31.2%)	0.79
Mucor spp	-	8(26.7 %)	(50.0 %)	9(18.8 %)	0.020
Trichophyton spp	-	4(13.3 %)	-	-	-
Alternaria spp	-	-	2(14.3 %)	6(12.5 %)	1.000
Cladosporum spp	-	-	-	7(14. 6 %)	-

Table 4-3: Mycoflora of fresh Nile perch from different markets in Kisii County

Mold	Keroka (n=15)	Daraja Mbili (n=25)	Nyakoe (n=20)	Riosiri (n=26)	P
Mucor spp	7(46.7%)	7(28.0%)	-	-	-
Alternaria spp	3(20.0%)	-	-	4(15.4 %)	1.000
Phome glomerate	5(33.3%)	-	-	-	-

Aspergillus spp	-	2(8.0%)	-	3(11.5 %)	1.000
Rhizopus spp	-	11(44.0%)	8(40.0%)	9 (34.7 %)	0.034
Penicillium spp	-	5(20.0%)	3(15.0%)	-	1.000
Cunninghamella spp	-	-	7(35.0%)	-	-
Trichoderma spp	-	-	2(10.0%)	3(11.5 %)	1.000
Cladosporium spp	-	-	-	7(26.9 %)	-

Table 4-4: Mycoflora of fresh catfish from different markets in Kisii County

Mold	Keroka (n=18)	Daraja Mbili (n=29)	Nyakoe (n=27)	Riosiri (n=28)	P
Rhizopus spp	-	11(37.9 %)	-	-	-
Aspergillus spp	-	3(10.3%)	-	4(14.3%)	0.996
Cladosporium spp	-	2(6.9%)	-	-	-
Candida spp	8(44.4%)	9(31.1%)	13(48.2%)	-	0.081
Cunninghamella spp	-	4(13.8%)	-	-	-
Acremonium spp	5(27.8%)	-	-	-	-
Mucor spp	4(22.2%)	-	9 (33.3 %)	8(28.6%)	0.149

Fusarium spp	1 (5.6%)	-	-	-	-
Penicillium spp	-	-	5 (18.5 %)	-	-
Mycosporum spp	-	-	-	6(21.4%)	-
Alternaria spp	-	-	-	3(10.7%)	-
Geotricum spp	-	-	-	7(25.0%)	-

Various fungal isolates were isolated from sun-dried *R. argentea*, tilapia, Nile perch and catfish. Their identity and percentage prevalence were as shown in Table 5 to 8. The molds whose prevalence were significant were Rhizopus stolonifer (p=0.014), *Aspergillus flavus* (p=0.045), *A. parasiticus* (p=0.028) and *Mucor* (P=0.015) in *R. argentea*, *A. fumigatus* (p=0.049), *Cladophialophora* sp (p=0.033) and *A. flavus* (p=0.018) in tilapia, *Mucor* sp (p=0.002), *A. flavus* (p=0.032), *Penicillium notatum* (p=0.012), *A. niger* (p=0.022) and *A. parasiticus* (p=0.022) in Nile perch, *A. niger* (p=0.031) and *A. flavus* (p=0.005) in catfish (table 3-5 to 3-8). It was observed that some sellers received money and used the same bare hands to pack fish for their customers (Plate 3-3). Some buyers also intentionally touched the displayed fish with their bare hands (Plate 3-4).

Table 4-5: Mycoflora of dried *R. argentea* from different markets in Kisii County

Mold	Keroka (n=58)	Daraja Mbili (n=40)	Nyakoe (n=49)	Riosiri (n=24)	P
Candida albicans	6(10.3 %)	4(10.0%)	-	-	1.00
Cladophialophora spp	3(5.2 %)	-	3(6.1%)	-	-
Penicillium notatum	5(8.6 %)		-	-	-
Acremonium spp	3(5.2 %)	-	-	3 (12.5 %)	-
Cunninghamella spp	4(6.9 %)	6(15.0%)	-	-	-

Phoma glomerate	5(8.6 %)	-	-	-	-
Aspergillus fumigatus	6(10.3 %)	-	-	-	-
Rhizopus stolonifera	6(10.3 %)	3(7.5 %)	6(12.2 %)	3 (12.5 %)	0.014
Aspergillus flavus	11(19.1%)	5(12.5%)	15(30.6%)	3 (12.5 %)	0.045
Aspergillus parasiticus	3(5.2 %)	4(10.0%)	5(10.2%)	-	0.028
Mucor spp	2(3.4 %)	2(5.0 %)	4 (8.2%)	2 (8.3 %)	0.015
Cladosporium spp	-	2 (5.0 %)	-	1 (4.2 %)	1.000
Aspergillus niger	-	6 (15.0%)	-	3 (12.5 %)	1.000
Fusarium chlamydosporium	-	4 (10.0%)	-	-	-
Fusarium solani	-	4 (10.0%)	-	2 (8.3 %)	-
Scopulariopsis spp	-	-	3 (6.1 %)	-	-
Geotricum candidum	-	-	6 (12.2 %)	-	-
Aspergillus ochraceus	-	-	5 (10.2 %)	-	-
Aspergillus glaucus	-	-	2 (4.1 %)	-	-
Verticillium spp	-	-	-	2 (8.3 %)	-
Trichoderma spp	-	-	-	3 (12.5 %)	-
Alternaria spp	-	-	-	1 (4.2 %)	-
Aspergillus terreus	-	-	-	1 (4.2 %)	-

Plate3-3 Fish seller holding money

Plate3-4 Fish buyer touching dried fish

Table 4-6: Mycoflora of dried tilapia from different markets in Kisii County

Molds	Keroka (n=45)	Daraja Mbili (n=27)	Nyakoe (n=38)	Riosiri (n=31)	P
Geotricum candidum	4(8.9 %)	-	3(7.9 %)	-	1.000
Penicillium citrinum	7(15.6 %)	3(11.1 %)	-	5(16.1 %)	0.163
Aspergillus fumigatus	6(13.3 %)	4(14.8 %)	5(13.2 %)	-	0.049
Phoma glomerate	5(11.1 %)	-	2(5.3 %)	-	1.000
Cunninghamella spp	3(6.7 %)	-	-	-	-
Acremonium spp	4(8.9 %)	-	-	-	-
Cladophialophora spp	3(6.7 %)	-	3(7.9 %)	4(12.9 %)	0.033
Aspergillus nuduluns	2(4.4 %)	-	(7.9 %)	-	1.000
Candida albicans	5(11.1 %)	5(18.5 %)	-	3(9.7 %)	0.083
Aspergillus flavus	6(13.3 %)	4(14.8 %)	10(26.3 %)	5(16.1 %)	0.018
Rhizopus stolonifera	-	3(11.1 %)	-	3(9.7 %)	-

Fusarium clamydosporum	-	2(7.5 %)	-	3(9.7 %)	1.000
Mucor spp	-	3(11.1 %)	-	-	-
Scopulariopsis	-	-	2(5.3 %)	-	-
Aspergillus ustus	-	-	4(10.4 5)	-	-
Phoma glomerate	-	-	2(5.3 %)	-	-
Aspergillus niger	-	3(11.1 %)	8(21.1 %)	3(9.7 %)	0.296
Verticillium spp	-	-	-	2 (6.5 %)	-
Mycosporium audouinii	-	-	-	2 (6.5 %)	-
Aspergillus terrus	-	-	-	1 (3.1 %)	-

Table 4-7: Mycoflora of dried Nile perch from different markets in Kisii County

Mold	Keroka (n=50)	Darja Mbili (n=26)	Nyakoe (n=32)	Riosiri (n=22)	P
Trichoderma spp	3 (6.0 %)	-	-	-	-
Mucor spp	2 (4.0 %)	3 (11.5 %)	3 (9.4 %)	3 (13.7 %)	0.002
Aspergillus flavus	9 (18.0 %)	5 (19.2 %)	6 (18.8 %)	2 (9.1 %)	0.032
Penicillium notutum	5 (10.0 %)	2 (7.7 %)	3 (9.4 %)	4 (18.1 %)	0.012
Aspergillus niger	6 (12.0 %)	5 (19.2 %)	2 (6.2 %)	3 (13.7 %)	0.022
Alternaria spp	3 (6.0 %)	-	-	-	`-
Acremonium spp	3 (6.0 %)	-	-	-	-

Cladophialophora spp	5 (10.0 %)	-	-	-	-
Aspergillus fumigatus	6 (12.0 %)	-	-	-	-
Aspergillus parasiticus	5 (10.0 %)	2 (7.7 %)	3 (9.4 %)	6 (27.2 %)	0.022
Rhizopus stolonifera	3 (6.0 %)	4 (15.2 %)	-	2 (9.1 %)	0.121
Fusarium solani	-	3 (11.5 %)	3 (9.4 %)	-	-
Phoma glomerata	-	2 (7.7 %)	-	-	-
Mycosporum versicolor	-	-	3 (9.4 %)	2 (9.1 %)	1.000
Scopulariopsis spp	-	-	4 (12.5 %)	-	-
Candida albicuns	-	-	3 (9.4 %)	-	-
Geotricum candidum	-	-	5 (15.5 %)	-	-

Table 4-8: Mycoflora of dried catfish from different markets in Kisii County

Mold	Keroka (n=39)	Dara Mbili (n=21)	Nyakoe (n=33)	Riosiri (n=39)	P
Cladophialophora spp	-	-	3(9.1%)	1(3.4%)	1.000
Mucor spp	-	3(14.3 %)	4(12.1 %)	-	1.000
Fusarium chlamydosporum	-	-	5(15.2 %)	3(10.3%)	0.997
Aspergillus terreus	-	-	3(9.1 %)	-	-
Scopulariospsis spp	-	-	2(6.1 %)	3(10.3%)	1.000
Aspergillus niger	7(17.9%)	-	5(15.2 %)	5(17.3%)	0.031
Aspergillus flavus	9(23.1%)	6(28.6 %)	6(18.2 %)	5(17.3%)	0.005
Geotricum candidum	-	-	1(3.0 %)	-	-

Rhizopus stolonifera	5(12.8%)	-	2(6.0 %)	-	1.000
Aspergillus parasiticus	-	-	2(6.0 %)	2(6.9 %)	-
Trichoderma spp	5(12. 8%)	-	-	-	-
Pennicillium notatum	3(7.7 %)	4(19.0 %)	-	6(20.7%)	0.134
Candida spp	2(5.2 %)	-	-	-	-
Cladosporium spp	8(20.5%)	-	-	-	-
Acremonium spp	-	2(9.5 %)	-	-	-
Aspergillus tamarii	-	1(4.8 %)	-	-	-
Aspergillus fumigatus	-	-	-	4(13.8%)	-
Aspergillus ochreceus		5(23.8 %)	-	-	-

Discussion

Mycoflora of fresh fish

Fifteen fungal species were isolated from fresh fish samples. They were *Cunninghamella*, *Rhizopus*, *Penicillium*, *Candida*, *Phoma glomerata*, *Trichoderma*, *Aspergillus*, *Mucor*, *Trichophyton*, *Alternaria*, *Cladosporium*, *Acremonium*, *Fusarium*, *Mycosporum* and *Geotricum* sp. Most of these fungi are ubiquitous and, therefore, can be found in the soil, on rocks, people's hands, unhygienic materials used for packaging and transporting the fish by fishermen, middlemen, wholesalers and retailers of fresh fish.

Samples of fresh *R. argentea* from Riosiri and Daraja Mbili markets had the highest number of fungal isolates which were 32 and 24 out of a total of 96 isolates respectively obtained from all the four markets. This was probably because they are the largest markets in Kisii County and they host so many people, some of whom touch the fish with their bare hands (Plate 3-2). Fish sellers handle money from different buyers and use the same hands to pack the fish for the buyers. This could have led to the transfer of fungal spores to the fresh fish from both the fish sellers and buyers. The fish samples were also displayed on dirty stands and gunny bags.

Penicillium sp was the most frequently isolated fungus. It was isolated from the four markets. This could be because it is considered to be a contaminant rather than a pathogen. However, many of its species produce citreoviridin and ochratoxin. This implies that its presence in fish can pose a health risk to its consumers. *Rhizopus stolonifer* was the second most frequently isolated. It was isolated from all the markets except Riosiri. *Cunnighamella* sp was isolated from Keroka and Riosiri markets while *Phome glomerata* was isolated from Daraja Mbili and Riosiri markets. Yeast and *Mucor* sp were the least isolated.

Cunninghamella species is widespread in distribution and is commonly found in soil and animal matter [14]. Animals such as cows, goats and poultry are sold in these markets during the market days. This could be the reason why it had a very high isolation frequency from the two markets (Keroka 50 % and Riosiri 31.1 %).

The fungal species that were associated with fresh tilapia were *Aspergillus*, *Trichoderma*, *Penicillium*, *Rhizopus*, *Mucor*, *Alternaria*, *Trichophyton* and *Cladosporium* spp. *Mucor* and *Rhizopus* sp were the most frequently isolated fungi. This could be because they grow very fast and produce many spores within a short time. The spores are blown by the wind, carried by animals and humans. This is why they are considered common contaminants of food.

Aspergillus flavus and *Aspergillus parasiticus* are known to cause invasive aspergillosis. They have been implicated in pulmonary, systemic, sinus, ear and other infections. They are the most reported food-borne fungi and can be found colonizing different types of foods and seeds [15]. They have also been implicated as both insect and animal pathogens [16]. Therefore, their presence in the fish samples raises a lot of health concerns.

Data from observations and interviews conducted during the study revealed that most fishermen, fish sellers and buyers do not observe the required simple hygiene guidelines such as refraining from touching the displayed fish with bare hands, use of clean materials for carrying, transporting and displaying fish. Handling of the fish during harvesting, processing and marketing could be a source of fungal contamination of the fish [17].

Mycoflora of dried fish

R. argentea recorded 166 out of 559 fungal isolates from the four markets. This was the highest among all other types of fish. This could be because their demand is quite high and therefore both retailers and wholesalers of this type of fish buy in bulk and store. If storage conditions are not conducive, contamination occurs. Another reason could be contamination by those who buy the fish as some touch the displayed fish with their hands (Plate 3-4). Most sellers of fish count money and use the same hands to pack the displayed fish (Plate 3-3) for the buyers. Given that many people consume this type of fish the level of such contamination is quite high.

Tilapia recorded the second largest number of isolates after *R. argentea* which was 141 out of a total of 559 isolates from the four markets. This could be due to contamination similar to that of *R. argentea*. Tilapia is also consumed by a large number of people and frequent touching of the fish when buying could be the cause of the high number of fungal isolates from it. Dried Nile perch and catfish are not as frequently consumed as tilapia and *R. argentea*. They are therefore not frequently contaminated. This could be the reason why they recorded the lowest number of isolates, i.e., 130 and 122 respectively.

Keroka market recorded the highest number of isolates (192 out of 559) for the four different types of fish. This could be because this market is there every day and sellers of fish display their fish daily. Since the market is located next to the Kisii-Keroka main road, a lot of dust, probably containing fungal spores, land daily on the fish. Contamination by fish buyers could also be occurring daily. This could be the same reason why samples from Nyakoe recorded the second-highest number of isolates (152 out of 559). Daraja Mbili and Riosiri markets recorded the lowest number of isolates, i.e., 109 and 106 respectively. These could be because in these two markets, the selling point for fish is far from the road, therefore, reducing contamination by dust from dusty roads.

The fungal species isolated from the dried fish sample included *Cladophialophora*, *Candida*, *Penicillium*, *Acremonium*, *Cunninghamella*, *Aspergillus fumigatus*, *Aspergillus flavus*, *Aspergillus parasiticus*, *A. niger*, *Fusarium*, *Scopulariopsis*, *Geotricum* spp, *Mucor spp*, *Trichoderma* and *Alternaria*. These fungi are food contaminants and are found in the soil. Their spores can easily be blown by wind and land on food. Makun et al. [18] isolated *Fusariums*, *Aspergillus*, *Aspergillus niger*, *Mucor*, *Penicillium* and *Geotricum* species from dry yam chips sold in Niger state in Nigeria. This is in agreement with the findings of this study.

The findings of this study concur with those by Bukola and Adebayo [19] who found out that *Cladosporium*, *Penicillium*, *candida*, *A. flavus*, *A. fumigatus*, *A. niger*, *Mucor* and *Fusarium* spp were associated with smoke-dried fish sold in Uyo Eastern Nigeria. However, they did not isolate *Mycosporum*, *Trichophyton*, *Cladophiarophora*, *Aspergillus nuduluns*, *Phoma glomerata*, *Geotricunm candidum*, *Aspergillus ustus*, *Trichoderma* spp, *Scopulariopsis*, *Rhizopus stolonifera*, *Verticillium*, *Alternaria* and *Acremonium* sp which were isolated from sun-dried fish during this study. As observed by Adebayo-Tayo and Ettah [1], who conducted a study in marketed bush mangoes seeds stored for sale in Uyo Nigeria, *A*. *flavus*, *A*. *parasiticus* and *A*. *fumigatus* occurred more frequently as compared to most of the other species. This concurs with the findings of this study.

A study by Adeyeye [20] on quality and safety assessment of sun-dried meat products from Ibadan, Oyo state Nigeria isolated 9 fungal strains from dried meat. The isolates were *A*. *flavus*, *A*. *niger*, *A*. *tamari*, *Fusarium compacticum*, *Fusarium oxysporum*, *Fusarium sacchari*, *Penicillium chrysogenum*, *Penicillium citrinum* and *Penicillium oxalicum*. This concurs with the findings of this study as all the fungal strains were isolated except for *Fusarium compacticum* and *Fusarium sacchari* which were not isolated. Job et al. [21] also isolated eight fungal genera which were *Fusarium*, *Aspergillus*, *Penicillium*, *Acremonium* and *Rhizopus* which were isolated during this study. However, *Saccharomyces*, *Schizosaccharomyces* and *Rhodotorula* which they isolated were not isolated during this study. Contrary to the findings of this study where *Aspergillus flavus* and *Penicillium notatum* were the most predominant species, Job *et al*. found out that *Penicillium digitatum* and *Fusarium equiseti* were the most predominant.

Observations made during the study showed that good hygiene practices (GHP) and hazard analysis critical control point (HACCP) were not observed along the production, processing and distribution line. This could be the reason why there was high fungal contamination of the dried fish. GHP and HACCP ensure that food products are produced under hygienic conditions and food safety measures are in place to address all possible risks that may be associated with the food product.

Storage of sun-dried fish

Most of the dried fish (89 %) had a moisture content of above 10 %, were not properly stored and had high CFUs. This concurs with the findings by Juli-Anne and Roy [22] who found out that moisture levels in feeds above 14 % and improper storage favoured the growth of aflatoxin producing molds. When such fish and feeds are stored improperly and for long periods of time the growth of fungi in them is accelerated. This results in increased CFUs and aflatoxin levels in the samples. This could be the reason why the samples that had high moisture content and had been stored for long had high CFUs. The atmospheric humidity in Kisii County in the two rainy seasons of the year increased to above 68 %. As observed by Juli-Anne and Roy [22], such humidity levels that are greater than 62 % favor the growth of molds and aflatoxin production. When exposed to the atmosphere for long, the dried fish absorb moisture from the surroundings. This is probably why the sampled dried fish had high moisture content.

Proper food storage is important in ensuring both food quality and safety. This is because improperly stored food can lead to spoilage causing huge economic losses and possible illness due to the consumption of aflatoxin contamination fish. Therefore, food safety can be ensured by maintaining proper storage conditions for fish.

Conclusion

The sun-dried fish sold in Kisii County are contaminated with aflatoxigenic fungi. This poses a health risk to consumers of these fish as it could lead to the consumption of aflatoxins.

Recommendation

There should be frequent detection of aflatoxigenic fungi in fish and sensitization on GHP and HACCP to fish sellers and buyers.

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CHAPTER FIVE

NUTRIENT RETENTION OF SOLAR-DRIED AFRICAN LEAFY VEGETABLES, KIAMBU COUNTY, KENYA

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Abstract

African leafy vegetables (ALVs) including pumpkin leaves (*Cucurbita maxima*), fig-leaf gourd (*Cucurbita ficifolius*), and stinging nettle (*Urtica dioica*) are underutilized vegetables with high nutritive value. The availability of these ALVs is seasonal and hence their preservation to be used during the dry spell is needed. One of the recommended methods of preserving ALVs is by solar drying. There is scarcity of information on the retention of iron, zinc, β-carotene, and vitamin C in pumpkin leaves, fig-leaf gourd, and stinging nettle subjected to solar drying. The objective of this study was to determine the effect of solar drying on the retention of iron, zinc, β-carotene, and vitamin C in pumpkin leaves, fig-leaf gourd, and stinging nettle. A 10kg batch of fresh vegetables was purchased from Kiambu market and appropriately packed and stored for processing and nutrient analysis. Iron and zinc were quantified using Atomic Absorption Spectrophotometer (AAS) while β-Carotene and vitamin C were quantified using reverse phase high performance liquid chromatography (HPLC). Results showed that the content of iron, zinc, beta carotene and vitamin C in fresh pumpkin leaves was 29.33 ± 0.47, 3.31 ± 0.06, 25.86 ± 0.01 and 118.734 ± 0.147 mg/100g dw respectively. In fresh fig-leaf gourd, the content of the nutrients was 25.381 ± 0.064, 5.505 ± 0.076, 18.46 ± 0.033 and 122.585 ± 0.093 mg of iron, zinc, β- carotene and vitamin C per 100g dw respectively. The iron, zinc, β- carotene and vitamin C content of fresh stinging nettle leaves were found to be 13.935 ± 0.138, 2.086 ± 0.041, 34.69 ± 0.14 and 228.6 ± 1.81mg/100g dw respectively. Solar drying of pumpkin leaves, fig-leaf gourd, and stinging nettle resulted in 98.8%, 99.5%, and 99.4% for iron respectively, 98.8%, 99.7%, and 99.1% for zinc respectively. The solar-dried vegetables showed a beta carotene retention of 78.5%, 82.8% and 71.09% respectively while vitamin C showed retention of 59.8%,72.2% and 61.1% in pumpkin leaves, fig-leaf gourd, and stinging nettle respectively. Solar drying had no significant ($p > 0.05$) effect on iron, zinc, β- carotene and vitamin C retention. The study revealed that the three ALVs of the study are sources of key nutrients and solar drying is a viable means of processing that would extend their shelf life and ensure all year round availability.

Keywords: nutrient retention, African leafy vegetables, blanching, solar drying

Background

African leafy vegetables have been documented to have a relatively high nutritional value when compared with exotic vegetables [1]. Vitamin A, iron, and zinc are nutrients of public health concern in Kenya and the world at large [2] African leafy vegetables including pumpkin leaves (*Crcurbita maxima*), fig-leaf gourd (*Cucurbita ficifolius*), and stinging nettle (*Urtica dioica*) are generally known to be rich in beta carotene (pro-vitamin A), iron, and zinc and other micronutrients. Also, most ALVs are drought-resistant crops and can withstand harsh desert climatic conditions [3]. However, research data shows that they are cultivated during rainy seasons and were previously regarded as weeds [4]. In Kenya most ALVs are underutilized due to seasonal variation. Micronutrient deficiency remains a major health challenge in many countries in Sub-Saharan Africa [5], [6]. In developing countries, majority of the people are poor and the diets are cereal-based with poor nutrient content and a few foods of animal origin [7]. African leafy vegetables are accessible to the low-income communities and therefore offer an opportunity for improving the nutritional status and food security of many poor families whose health and nutrition are at risk. African leafy vegetables have been in decline due to the introduction of foreign vegetables while the low consumption of the ALVs may be due to low availability and little knowledge [8]. Limited data on the nutrient content of these ALVs may also be attributed to low consumption [6]. To ensure all year round availability of ALVs for improved consumption, there is a need to explore appropriate ways that can be adopted by rural communities to preserve leafy vegetables for use during dry spells when production plummets. The advantage of using solar driers compared to other methods of drying includes: the solar driers have a high rate of drying due to increased high temperature, the movement of air and also low humidity. The vegetables to be solar-dried are also protected from dust, insects, birds and animals. The driers are waterproof hence require no movement in case of rain. The solar driers can be constructed using locally available materials at a low cost.

Purpose of the Study

The purpose of this study was to investigate the effect of solar drying on the retention of iron, zinc, and β-carotene (pro-Vitamin A) and vitamin C (ascorbic acid) in pumpkin leaves (*Cucurbita maxima)*, stinging nettle (*Urtica dioica)* and fig-leaf gourd (*Cucumis ficifolius)*.

Materials and methods

Three vegetable species pumpkin leaves (*Cucurbita maxima)*, stinging nettle (*Urtica dioica)* and fig-leaf gourd (*Cucumis ficifolius)* were purchased from Ruiru market early in the morning as they were delivered from their place of origin which is in Kiambu County.

Vegetable acquisition and preparation

A batch of 10 kilograms of fresh pumpkin leaves (*Cucurbita maxima*), stinging nettle (*Urtica dioica*) leaves and fig-leaf gourd (*Cucurbita ficifolia)* leaves were purchased early in the morning from Ruiru market as they were being delivered from their origin in Kiambu County, packaged in perforated polythene bags and immediately transported to Kenyatta University laboratories for processing and nutrient analysis using a cool box at 15^0C. The samples were stored in a refrigerator at 5^0C before processing and nutrient analysis. The vegetables were prepared by sorting and separating the leaves from the stalks, followed by washing under cold distilled water. The cleaned leaves were then placed in a cooking pot with hot water whereby they were water-blanched for 5 min to inactivate enzymes and fix color followed by cooling in distilled ice water for 30 seconds and straining to remove excess water. The leaves were then introduced onto the drying trays and evenly spread without overlapping. The trays were then placed into the solar boxes for drying. Drying proceeded until a moisture content of 4-8% was attained as determined by oven drying for 3 hours at 105^0C. The dried vegetables were then packaged in sealed polythene bags to prevent reabsorption of moisture, and they were stored in the dark at room temperature prior to nutrient analysis**.**

Extraction and HPLC analysis of β-carotene (Pro-vitamin A)

Beta-carotene was extracted according to Chege et al. [9]. Five grams of the vegetables were weighed using an analytical balance (NBY323/64) and ground using a pestle and mortar followed by transferring into a 250 ml conical flask. Thereafter, 50 ml of a mixture of acetone and hexane (3:2 v/v) containing 0.1% Butylated Hydroxytoluene (BHT) was added. The BHT was used to prevent the oxidation of the β-carotene in the vegetables. The mixture was then mechanically shaken for 10 minutes followed by centrifuging the solution for 10 minutes at 1000 rpm to separate the vegetable-solvent mixture into two layers. The organic solvent layer was transferred into a separating funnel and 25ml of methanolic potassium hydroxide (0.5M) was added to saponify the potentially interfering oils. The saponified extract was then shaken and allowed to settle for 30 minutes followed by washing the solution with 100ml of 10% sodium chloride solution and three more times with distilled water to remove the acetone while discarding the aqueous layer continuously. The extract was then filtered over anhydrous sodium sulphate and then concentrated in a rotary evaporator at 45^oC. The filtrate was then reconstituted to 50ml using methanol in a 50 ml volumetric flask. The volumetric flask was covered with aluminum foil to minimize the destruction of β- carotene by light.

Beta-carotene concentration was determined according to the method of [10]. Exactly 20 µl of standard and sample solution was injected into reverse-phase high performance liquid chromatography (Shimadzu 20A Kyoto, Japan) consisting of a column oven (CTO –10 AS VP), a degasser (DGU – 20A5R), an LC pump (LC- 20AD) a UV–Visible diode- array detector (SPD -20A) and an autosampler (SIL-20AHT). Sample elution was carried out using a reverse-phase C_{18} column (Phenomenex C18, 250 x 4.6 mm, 5µm particle size, Luna 5u) using a mobile phase consisting of acetonitrile, dichloromethane and methanol in the ratio of 70:20:10 respectively at the flow rate of 2 ml/ minute. Detection of β-carotene was achieved using a UV–detector (Shimadzu SPD – 20A model) at 452 nm.

Beta-carotene standard solution was prepared by weighing 10 mg of 95% UV β - carotene Type 1 (Sigma Aldrich) in 100 ml volumetric flask and the solution made to the mark with 100 ml n-Hexane giving a concentration equal to 100 ppm. Different known concentrations, i.e.20, 40, 60, 80 ppm were prepared by diluting the stock solution with hexane. β-carotene standard curve was obtained by plotting the peak area against various concentrations of the standard. The concentration of β-carotene in the samples was obtained by extrapolation from the standard curve.

Extraction and HPLC analysis of ascorbic acid (vitamin C)

Vitamin C was quantified in the form of ascorbic acid (AA) and was extracted according to the procedure described by Macrae, Robinson, and Sadler [11]. Ten grams of the vegetable samples were ground using a pestle and mortar and then mixed with 50 ml of extracting solution. The extract was filtered using filter paper (Whatman no. 42) and transferred to a 100 ml volumetric flask and made it to the mark with an extraction solution. The extraction solution consisted of 3% metaphosphoric acid (MPA) and 8% acetic acid prepared by dissolving 15g of MPA in 40ml acetic acid and 200 ml of distilled water and made to the 500 ml mark using distilled water.

Ascorbic acid standard (100 mg) was weighed using an analytical balance (NBY323/64) into a 100 ml beaker and dissolved with 45 ml of the extraction solution. The solution was then transferred into a 100 ml volumetric flask followed by rinsing the beaker three times with extraction solution and transferring the solution to the volumetric flask. The volumetric flask was then filled to the mark using the extraction solution and the concentration was equal to 1000 ppm. Standards of different known concentrations, i.e. 10, 20, 40, 60, 80, and 100 ppm were prepared by diluting the stock solution with the extraction solution and used for preparing the standard curve.

The concentration of vitamin C was determined after the sample extracts were centrifuged at 10,000 rpm. The supernatant was then filtered and diluted with 10 ml of 0.8% metaphosphoric acid which was later passed through a 0.45 μm membrane filter. Identification and quantification of vitamin C was performed using Reverse Phase High Performance Liquid Chromatography (Shimadzu 20A Kyoto, Japan) consisting of a column oven (CTO –10 AS VP), a degasser (DGU – 20A5R), an LC pump (LC-

20AD) a UV – Visible diode- array detector (SPD -20A) and an autosampler (IL-20AHT). Sample separation was carried out in a reverse phase C_{18} column (Phenomenex C18, 250 x 4.6mm, 5µm particle size, Luna 5u).

The elution of AA was done using a mobile phase consisting of 0.8% metaphosphoric acid at a flow rate of 1.2ml/ min [12]. The AA was detected at 266 nm using a prominence UV/VIS detector (Shimadzu UFLC SPD-20A). Exactly 20 µl of standard and sample extract were injected into the column. The concentration of AA in the sample was obtained by extrapolation from the standard curve.

Digestion of vegetable samples for iron and zinc analysis

Digestion of vegetable samples for iron and zinc analysis was done according to the procedure described by Wakhanu et al. [13]. About 1 g of the vegetable was weighed into a 250 ml digestion tube followed by adding 10 ml of concentrated nitric acid. The mixture was then heated at 90^{O}C in an electric hot plate for 10 minutes followed by dropwise addition of 30% hydrogen peroxide until the solution was clear. The digested sample was then filtered using filter paper (Whatman no. 1) into a 100 ml volumetric flask and made to the mark with distilled water. The solution was then transferred into a labeled plastic container waiting for analysis.

Each zinc and iron standard of 1000 ppm (Sigma Aldrich) was used to prepare a stock solution by dissolving 25 ml of 1000 ppm in 50 ml distilled water, then transferred quantitatively into a 250 ml volumetric flask and making to the mark using distilled water. The concentration of the resulting solutions was equal to 100 ppm

Preparation of the working standard of 2, 4, 6, 8 ppm was conducted by diluting the stock solution of iron and Zinc with distilled water. Zinc and iron standard curves were prepared by plotting the concentrations of zinc/ iron against their absorbance. The standard and the sample were analyzed using FAAS at 213.9 nm with a slit of 0.7 nm using air acetylene flame at a flow rate of 2.0 l/ min, lamp mode BGC-D_2 and lamp current of 12 mA, while iron was analyzed at 248.3 nm with a slit of 0.2 nm using air acetylene flame and a flow rate of 2.2 l/ min, lamp mode BGC-D_2 and lamp current of 12 mA. The standards and samples were analyzed in triplicate and the mean concentration of each sample calculated.

Research permit and ethical considerations

A research permit was obtained from the National Council for Science, Technology, and Innovation (NACOSTI). Ethical clearance was sought from Kenyatta University Ethical Review Committee (KUERC).

Results and discussion

Nutrient retention in solar dried pumpkin, fig-leaf gourd, and stinging nettle leaves

In the current study, solar drying decreased the content of β-carotene and vitamin C in the three vegetables but not that of zinc and iron. Vitamin C content of three ALVs was significantly lower after solar drying. Solar-drying of the three ALVs resulted in significantly lower values of β-carotene compared to the values in the fresh samples (Table 5-1, 5-2 & 5-3). In the current study, pumpkin leaves after solar drying had retention of 59.8% vitamin C content compared to when the pumpkin leaves were blanched for 5 minutes and solar dried which had retention of 42.7 %. The retention of vitamin C in blanched pumpkin leaves was 50.9% compared to fresh pumpkin leaves on the vitamin C content. This falls below the values of 81 and 75%, reported by Munyaka et al 2010 [15] for the retention of treated and untreated blanched broccoli vegetables respectively. Solar drying led to significant decreases in both the β-carotene. The results indicate that solar drying leads to significant reductions in the contents of the vitamins in stinging nettle leaves.

Current results show that solar drying did not have any significant effect on the mineral content of the vegetables. There was high retention of over 98% for both iron and zinc in all three vegetables. Other researchers have similarly reported high retention of the minerals in solar-dried vegetables. As pointed out by Stanley et al., (2017) [14], dehydration of vegetables generally does not significantly affect the total mineral content or the contents of the individual minerals.

Table 5-1. Retention of nutrients in pumpkin leaves
Values in parenthesis indicate the percent of nutrient retention in treated samples relative to fresh samples

Sample	Nutrient content (mg/100g dw)			
Nutrient	Iron	Zinc	β-carotene	Vitamin C
FL	29.331±0.474 (100)	3.307±0.055 (100)	25.86±0.08 (100)	118.734±0.147 (100)
BL	28.381±0.475(96.8)	3.158±0.037 (95.5)	25.67±0.06 (99.3)	60.486±0.095 (50.9)
UBSL	28.980±0.637 (98.8)	3.266±0.035 (98.8)	20.30±0.22 (78.5)	70.955±0.142 (59.8)
BSL	27.675±0.224 (94.4)	3.141±0.069 (95.0)	23.23±0.08 (89.8)	50.748±0.024 (42.7)

Key: FL = fresh leaves ∞ BL = blanched leaves ∞ UBSL = unblanched solar-dried leaves BSL = blanched solar-dried leaves

Table 5-2: Retention of nutrients in fig-leaf gourd.
Values in parenthesis indicate the percent of nutrient retention in treated samples relative to fresh samples

Sample	Nutrient content (mg/100g dw)			
Nutrient	Iron	Zinc	β-carotene	Vitamin C
FL	25.381±0.064 (100)	5.505±0.076 (100)	18.46±0.033 (100)	122.585±0.093 (100)
BL	25.246±0.204 (99.5)	5.225±0.021 (94.9)	19.14±0.010 (103.7)	65.379±1.188 (53.3)
UBSL	25.269±0.079 (99.5)	5.487±0.012 (99.7)	15.29±0.006 (82.8)	88.525±0.683 (72.2)
BSL	25.138±0.035 (99.0)	5.198±0.037 (94.4)	16.63±0.000 (90.1)	59.690±0.924 (48.7)

Key: FL = fresh leaves ∞ BL = blanched leaves ∞ UBSL = unblanched solar-dried leaves BSL = blanched solar-dried leaves

Table 5-3: Retention (mg/100g dw) of nutrients in stinging nettle leaves

Values in parenthesis indicate the percent of nutrient retention in treated samples relative to fresh samples

Sample	Nutrient content per 100g dw			
Nutrient	Iron	Zinc	β-carotene	Vitamin C
FL	13.935±0.138	2.086±0.041	34.69±1.43(100)	228.6±0.18
	(100)	(100)	34.65±0.65(99.9)	(100)
BL	13.383±0.059	1.909±0.012	24.66±1.69(71.1)	120.12±0.16
	(96.0)	(91.5)	23.06±2.27(66.5)	(52.5)
UBSL	13.857±0.051	2.067±0.044		139.62±0.12
	(99.4)	(99.1)		(61.1)
BSL	13.367±0.036	1.826±0.023		87.56±0.10
	(95.9)	(87.5)		(38.3)

Key: FL = fresh leaves ∞ BL = blanched leaves ∞ UBSL = unblanched solar-dried leaves BSL = blanched solar-dried leaves

Effect of different treatments on the nutrient content of vegetable samples

Pumpkin Leaves

In this study, the fresh and unblanched solar-dried pumpkin leaves were found to have the highest concentration of zinc. The zinc contents of both blanched and solar-dried pumpkin leaves samples were not significantly different from that of fresh samples. Vitamin C content of pumpkin leaves was significantly lower after each of the processing treatments (blanching, and solar-drying as well as combined treatments). There was no significant difference in β-carotene content between fresh and blanched samples.

Table 5-4: Mean nutrient content of fresh and treated pumpkin leaves

Sample	Nutrient content per mg/ 100g dw			
Nutrient	Iron	Zinc	β-carotene	Vitamin C
FL	29.331±0.474^{a}	3.307±0.055^{a}	25.86±0.08^{a}	118.734±0.147^{a}
BL	28.381±0.475^{b}	3.058±0.037^{ab}	25.67±0.06^{a}	60.486±0.095^{b}
UBSL	28.980±0.637^{ab}	3.266±0.035^{a}	20.30±0.22^{d}	70.955±0.142^{e}
BSL	27.675±0.224^{cd}	3.141±0.069^{ad}	23.23±0.08^{e}	50.748±0.024^{f}

Key: FL = fresh leaves ∞ BL = blanched leaves ∞ UBSL = unblanched solar-dried leaves BSL = blanched

Solar-dried leaves. Superscripts with different letters in the same column indicate significantly different values at $p \leq 0.05$

Fig-leaf gourd

As shown in Table 5-5, post-hoc analysis (LSD) revealed that iron contents of both blanched and solar dried samples were lower relative to fresh samples although the difference was not significant (p>0.05). Zinc content in both blanched and unblanched cooked fig- leaf gourd was significantly lower than that of fresh samples. However, there was no significant difference in the zinc content of fresh fig- leaf gourd and solar dried fig- leaf gourd samples. Vitamin C contents of the fig- leaf gourd vegetable samples were significantly reduced after each of the three processing treatment (blanching and solar drying) relative to fresh samples.

Table 5-5: Mean values for nutrient content of fig-leaf gourd samples

Sample	Nutrient content per mg/100g dw			
Nutrient	Iron	Zinc	β-carotene	Vitamin C
FL	25.381 ± 0.064^{a}	5.505 ± 0.076^{a}	18.46 ± 0.33^{a}	122.585 ± 0.093^{a}
BL	25.246 ± 0.204^{ab}	5.225 ± 0.021^{b}	19.14 ± 0.10^{b}	65.379 ± 1.188^{b}
UBSL	25.269 ± 0.079^{ab}	5.487 ± 0.012^{a}	15.29 ± 0.06^{e}	88.525 ± 0.683^{e}
BSL	25.138 ± 0.035^{b}	5.198 ± 0.037^{b}	16.63 ± 0.01^{f}	59.690 ± 0.924^{f}

Key: FL = fresh leaves ∞ BL = blanched leaves UBSL = unblanched solar-dried leaves ∞ BSL = blanched solar-dried leaves

Stinging nettle

The iron content of blanched (BL) (13.383±0.059 mg/100g dw) and blanched solar-dried (BSL) (13.367±0.036mg/100g dw) stinging nettle leaves were significantly lower than that of fresh samples. However, the difference between the iron contents of fresh and solar-dried samples was not significant. Likewise, the drop in zinc content of stinging nettle leaves during solar drying was not significant relative to the original content in fresh samples. However, zinc content of both blanched and blanched solar-dried stinging nettle samples was significantly lower fresh leaves. An insignificant drop was realized in the content of β-carotene of both blanched and blanched solar-dried stinging nettle leaves relative to fresh leaves while content of β-carotene in solar-dried leaves was significantly lower than fresh leaves.

Table 5-6: Mean values for nutrient content of stinging nettle leaves samples

Sample	Nutrient content per mg/ 100g dw			
Nutrient	Iron	Zinc	β-carotene	Vitamin C
FL	13.935±0.138[a]	2.086±0.041[a]	34.69±1.43[a]	228.60±0.18[a]
BL	13.383±0.059[b]	1.839±0.012[b]	34.65±0.65[a]	120.12±0.16[b]
UBSL	13.857±0.051[a]	2.067±0.044[a]	24.66±1.69[c]	139.62±0.12[e]
BSL	13.367±0.036[b]	1.826±0.023[b]	23.06±2.27[c]	87.56±0.10[f]

Key: FL = fresh leaves ∞ BL = blanched leaves UBSL = unblanched solar-dried leaves ∞ BSL = blanched solar-dried leaves

Conclusion and Recommendation

The leaves of pumpkin, fig leaf gourd, and stinging nettle are good sources of iron, zinc, vitamin C and beta carotene and can be used to combat the deficiency of these micronutrients in Kenya. In addition, solar drying of pumpkin, stinging nettle, and fig-leaf gourd leaves is an effective method of preservation and can be used to close the seasonal gaps. Since drying of green leafy vegetables leads to concentration of nutrients per unit the use of a relatively small amount of pumpkin leaves, stinging nettle, and fig-leaf gourd can significantly raise the content of β-carotene, iron, and zinc in the diet and enables the population to meet the RDAs for these micronutrients. This study recommends the use of solar drying as a viable strategy to address the seasonality gaps while ensuring retention of these essential nutrients.

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CHAPTER SIX

THE INFLUENCE AND COMPLIANCE OF THE APPLICATION OF INTERNATIONAL FOOD SAFETY STANDARDS IN 5 STAR HOTELS IN NAIROBI, KENYA

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Abstract

Ailments spread through ingested foods remain a common and persistent problem resulting in considerable illness and occasional mortality. Ensuring food safety in hotels is, therefore, not only important for business but also the wellbeing and safety of hotel clients. In the recent past, there have been press reports of several cases related to foodborne illness that has highlighted and increased visibility of hygiene and food safety in hotels. As a consequence, this study aimed to assess the influence and compliance of the application of International Food Safety Standards in 5 star hotels in Nairobi, Kenya. The objective was to conduct a study of management practices, policies and resource provision concerning food safety and assess the levels of compliance to international food hygiene standards in 5 star hotels in Nairobi. Nairobi has a population of eight 5 star hotels and 5 hotels were selected for the research. The study adopted a cross-sectional survey design, while research instruments included questionnaires, interview schedules and observation checklists that targeted food handlers and managers. Descriptive statistical findings were presented in figures, tables, narrative and descriptive forms. The T-test and chi-square established that there was a statistically significant change in food safety as a result of the application of food safety standard systems, (β=.202, p = .029) a positive and statistically significant relation with food safety standards in hotels in Nairobi. The results reveal that there exists a strong relationship among the selected independent variables and

provision of safe food as indicated by the correlation coefficient of 75.2 %. From the findings, the study concluded that the application of standard food safety systems and implementation of and compliance to food safety standards of food safety systems influence the provision of safe food in 5 star hotels in Nairobi.

Key Words: HACCP, food Safety, standards, 5-Star Hotels, Kenya.

Background

International food safety standards

The United Nations' Food and Agriculture Organization (FAO) was founded in 1945, its mandate included nutrition and associated food standards. The responsibility of the World Health Organization (WHO), created in 1948, encompassed human health as well as the establishment of food standards [1]. An FAO Regional Conference for Europe, in 1960, endorsed the idea of an international agreement on minimum food standards. The Codex Alimentarius Commission was created as a joint FAO/WHO program. Its declared purpose was to protect the health of consumers and ensure fair practices in food trade [2]. International Food Safety Standards are regulations containing requirements, specifications, guidelines or characteristics that can be used to consistently ensure that food materials, products, processes and services produced are fit for human consumption. Emphasis on mass food safety will remain prominent for now and the future, in the hospitality industry and wherever else groups of people are fed. Five major factors that lead to foodborne illness have been identified by the WHO. Lack of hygiene and sanitation by the food handlers, together with improper cooking procedures; temperature abuse during storage; cross-contamination between fresh ready-to-eat foods and raw foods; the purchase process and acquiring raw food material from risky sources, make up the list of five.

Food safety systems are established, operated and updated within the framework of a structured management system and incorporated into the overall management activities of an organization. International standard specifies requirements for a food safety management system that involves interactive communication, system management, prerequisite programs and HACCP principles.

In the recent past, there have been press reports of a number of cases related to foodborne illness in Nairobi County and the increased visibility of such cases highlights food safety concerns in hotels. Food safety is defined as the assurance that food will not cause harm to the consumer when it is prepared and/ or eaten in accordance with its intended use and is a specific aspect of food quality. Contaminated food can result in food poisoning if not guarded against hazards and can do more harm to the eater than the good it is intended. Depending on the severity of the poisoning, it can result in either illness or death [3]. Management of hotel food safety effectiveness is only possible if everyone involved is aware of and adheres to established food safety standards procedures and practices. Non-adherence and mismanagement of food safety practices enable pathogens to multiply and contaminate the food. The potential impact of foodborne illness outbreaks in a hotel or food outlet can be devastating. Serious economic loses will occur if hygiene standards are compromised. Since tourism is so important, there is a possibility that some guests and event organizers may not come to Kenya for fear of food safety.

Application of food safety standards

The objective was to evaluate the application of international food safety standards in 5-star hotels in Nairobi. Both descriptive and inferential statistical analysis was carried out for this purpose.

Research design

A cross-sectional survey stood as the most suitable research design for achieving the purpose of this study. It is used for establishing the spread of certain traits, associations and relationships of a given population. The survey provides wide and inclusive coverage and therefore a panoramic and representative view of the population under study.

The location of the study was Nairobi City County in Kenya. Nairobi is very unique; being a financial hub and the largest city in Eastern Africa, blending vast tourism attractions with business opportunities, in the region, as well as attracting major conferences and other events. The hospitality industry in Kenya is developing rapidly with a huge number of hotels being opened. Nairobi has several hotels including 5-star rated hotels located conveniently in the central business district while others are on its outskirts that play host to a large number of all kinds of visitors.

The target population of the study consisted of all the 5 star hotels in the central business district of Nairobi. According to hotel census results published in the gazette notice [4] (Vol. CXVII-No. I43) in November 2017, eight hotels in Nairobi County qualified for the five-star rating by the Tourism Regulatory Authority.

The hotel industry in Kenya has diversity in the category of hotels that is available to guests. Consequently, several 5 star hotels are located conveniently in the central business district while others are on the outskirts of the main city. The hotels were selected because they have fully serviced food establishments and outlets that are often the preferred choice by visitors who are conscious of food safety. Food is very sensitive and personal, as it is the only service that is ingested by a hotel client.

Sampling design

The researcher used purposive sampling to select the samples from the hotels based on the information and knowledge of the objectives of the study. The respondents were purposively drawn from the kitchen, service and stores section as they are directly involved in the handling of food at all stages. The study employed random sampling to obtain respondents from the selected sections, where the researcher adopted two levels of sampling. The intention was to ensure inclusivity of all the food handlers in the population. At the first level, respondents from the hotels consisted of the administrative heads of the units and included the F&B manager and chef who are responsible for maintenance and compliance of food safety standards in their different sections. The second level of sampling was carried out with respect to implementers, the cooks, cleaners, waiter as the food handlers, together with the storekeepers to obtain the respondents.

Sample size

A total of 185 respondents participated in the study from a targeted 231 respondents. The number of questionnaires distributed was 231 and a total of 185 questionnaires were returned.

The response rate indicates a return rate of 80.1%. A response rate of above 50% is adequate for a descriptive study. Further, Babbie [5] confirms that response rates of above 50% are acceptable for analysis, 60% is good, 70% is very good while above 80% is excellent.

Research instruments

A researcher may use more than one method of data collection to test hypotheses and assess variables to reduce the degree of dependence on specific methods that may limit the authenticity or extent of the findings. Primary data was collected using questionnaires for employees, while an interview schedule was used for the administrative heads. The questions were a mixture of both open-ended and closed format questions. This study employed the use of a Likert scale for some questions. Respondents were given the freedom to respond using their own words with the open-ended questions.

Data collection method

Primary data was collected through the use of structured self-filling questionnaires. The questionnaires were distributed to the respondents by the researcher and research assistants, through hard copies and email. An observation checklist containing items of assessment of hygiene and sanitation was used to collect information on the state of affairs and sanitary working conditions of the hotels. The tools and approach allowed the researcher to collect a large amount of data in a relatively short time.

Data analysis and presentation

Both inferential and descriptive statistics were used to analyze data. The data was checked for completeness, accuracy, consistency and uniformity. Descriptive statistics such as averages, variances, frequencies, standard deviations and percentages was used to analyze the data. Research findings were presented in narrative and descriptive form, figures, graphs and bar charts. Inferential statistics such as t-test and anova were used to measure between and within dependent and independent variables. Multiple regression analysis and Chi-square tests were used to establish relationships. All inferences and conclusions of the study were made at 95% confidence level. Rejection criteria, therefore, involved rejecting the null hypothesis whenever the p-value was less than the significance level of the test ($p\text{-}value < 0.05$).

Results, findings and discussion

The study evaluated the application of aspects of the food safety system in 5-star hotels.

The participants of the study responded to statements related to the application of the standard food safety system. The result findings are presented in Table 6-1.

Table 6-1: Application of food safety standards

Food Safety system	**yes**	**No**	**Don't know**	**Mean**	**Std. Dev**
Hotel has food safety control aspects	88.1%	8.6%	3.2%	1.2	0.4
Receiving food only from approved suppliers	79.5%	12.4%	8.1%	1.3	0.6
HACCP procedures at every step in the production process	80.5%	13.0%	6.5%	1.3	0.6
Safe Storage conditions of all food	89.2%	10.8%	0.0%	1.1	0.3
Protection from contamination – stored away from chemicals, physical and biological contaminants	85.4%	14.6%	0.0%	1.1	0.4
Average				**1.2**	**0.5**

The results presented in Table 6-1 reveal that 88.1% agreed that the hotel observes hotel food safety control aspects. The results also showed that majority of the respondents 79.5% indicated that the hotel receives food only from approved suppliers and that quality control is frequently observed while receiving the food items, where the quality in terms of freshness, weight, packaging and quantity is checked as per specifications given on the purchase order.

80.5% of the participants agreed that the hotel follows HACCP procedures at every step in the production process. The effectiveness of HACCP depends on the skills and knowledge of staff and management. Before implementation, prerequisite programmes such as documented standard operating procedures, good hygienic practices, and staff training are appropriately instituted.

Further, 89.2% of the respondents agreed that the hotel observes safe storage conditions of all food, while 85.4% of the respondents agreed that the hotel observes protection from contamination – storing away from chemicals, physical and biological contaminants.

The average response was 1.2, an indication that the majority of the respondents were in agreement that the hotel does have in place a food safety system. The standard deviation was 0.5, an indication that responses were clustered around the average mean response.

Paired t-test between the application of food safety standards and food safety was computed to see if there is any statistically significant change in food safety. The paired t-test is presented in Table 6-2. The p value is 0.000<0.05 and therefore the study concludes that there is a statistically significant change in food safety as a result of applying food safety standards. The results are in agreement with Wandolo [6] that HACCP prerequisites are critical in ensuring food safety.

Table 6-2: Paired t-test

		Mean	Std. Deviation	95% CI			
				Lower	Upper		
Pair 1	Food Safety systems Food safety	-.4703	1.24	-.53	-.17	-3.82	.000

Cross-tabulation between the application of food safety standards and food safety

A cross-tabulation table was presented to illustrate food safety for those hotels that observe the application of food safety standards. The cross-tabulation results are presented in Table 6-3.

The results showed that hotel food safety control aspects and food safety are statistically significant supported by a chi-square of 25.505 and a reported p value of (0.000) which was less than (0.05) level of significance. The chi-square results show that there is a significant association between hotel food safety control aspects and the provision of safe food. Receiving food only from approved suppliers and food safety is statistically significant as supported by a chi-square of 27.145 and a reported p value 0.000<0.05. The chi-square results show that there is a significant association between receiving food only from approved suppliers and the provision of safe food.

Table 6-3: Cross-tabulation between the application of food safety standards and food safety

		Food	safety		
		Safe	**not safe**	**χ**	**p-value**
Hotel food safety control aspects	yes	91	42		
	no	11	30		
	Don't know	7	4	25.505	0.000
Receiving food only from approved suppliers	yes	93	39		
	no	10	30		
	Don't know	6	7	27.145	0.000
HACCP procedures at every step in the production process	yes	100	43		
	no	6	30		
	Don't know	3	3	33.913	0.000
Storage conditions of all food	yes	101	44		
	no	8	32		
	Don't know	-		31.937	0.000
Protection from contamination - away from chemicals, physical and biological contaminants	yes	100	44		
	no	9	32		
	Don't know	-		29.74	0.000

Adherence to HACCP procedures at every step in the production process and food safety are statistically significant supported by a chi-square of

33.913 and a reported p value 0.000<0.05. The chi-square results show that there is a significant association between HACCP procedures at every step in the production process and the provision of safe food. Storage conditions of all food and food safety are statistically significant supported by a chi-square of 31.937and a reported p value 0.000<0.05. The chi-square results show that there is a significant association between the storage conditions of all food and the provision of safe food. Receiving food only from approved suppliers and food safety are statistically significant supported by a chi-square of 27.145 and a reported p value 0.000<0.05. The chi-square results show that there is a significant association between receiving food only from approved suppliers and the provision of safe food. Further, it was also established that protection from contamination - away from chemicals, physical and biological contaminants and food safety are statistically significant supported by a chi-square of 25.505 and a reported p value 0.000<0.05. The chi-square results show that there is a significant association between protection from contamination away from chemicals, physical and biological contaminants and food safety.

4.3.4 Correlation analysis for application of food safety standards

The study sought to establish the association among the indicators for the application of food safety standards and food safety. The results are as presented in Table 6-4.

The results indicated that hotel food safety control aspects (r=.688**, p=0.000) indicated a positive significant association with food safety. Receiving food only from approved suppliers had a strong positive and significant association with food safety (r= .831**, p=0.000). Results further showed that HACCP procedures at every step in the production process had a strong positive significant association with food safety (r= .824**, p=.187). Storage conditions of all food also indicated a positive association with food safety (r= .685**, p=.000). It was also noted that protection from contamination away from chemicals, physical and biological contaminants had a positive significant association with food safety (r= .614**, p=.187).

Table 6-4: Correlation matrix for application of food safety standards

		Food safety	Hotel food safety control aspects	Receiving food from approved suppliers	HACCP procedures at every step	Storage conditions of all food	Protection from contamination
Food safety	Pearson Correlation	1.000					
Hotel food safety control aspects	Pearson Correlation	.688**	1.000				
Receiving food only from approved suppliers	Pearson Correlation	.831**	.406**	1.000			
HACCP procedures at every step in the production process	Pearson Correlation	.824**	.449**	.728**	1.000		
Storage conditions of all food	Pearson Correlation	.685**	.434**	.353**	.332**	1.000	
Protection from contamination -	Pearson Correlation	.614**	.276**	.310**	.270**	.744**	1.000

** Correlation is significant at the 0.01 level (2-tailed).

Application of food safety standards and food safety regression analysis

Table 6-6 presents the model fit statistics for the regression model fitted to the data. The results show that the application of food safety standards explained 43.8% of the variation in food safety. The results agree with Wandolo [6] that HACCP prerequisites are critical in ensuring food safety.

Table 6-5: Model fit

Model	R	R Square	Adjusted Square	RStd. Error of the Estimate
	.662	.438	.436	.486

The regression coefficients' results are presented in Table 6. From the analysis, hotel food safety control aspects were found to have a positive and significant relationship with food safety (β=.112, $p=0.003<0.05$). This means that a unitary increase in the application of food safety systems will lead to a corresponding 0.172-unit increase in safe food provision. Receiving food only from approved suppliers and food safety were positively and significantly related (β=.068, $p=0.040<0.05$). HACCP procedures at every step in the production process was found to have a positive and significant relationship with food safety (β=.386, $p=0.000<0.05$). Storage conditions of all food and food safety were positively and significantly related (β=.122, $p=0.027<0.05$) while protection from contamination away from chemicals, physical and biological contaminants and food safety were positively and significantly related (β=.134, $p=0.000<0.05$). This implies that the application of food safety standards enhances food safety. In an interview, manager 4 indicated:

> *"The hotel management is committed to serving safe food by implementing food safety standards."*

Table 6-6: Regression coefficients

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	2.229	.338		6.595	.000
	Hotel food safety control aspects	.112	.027	.043	4.148	.003
	Receiving food only from approved suppliers	.068	.024	.036	2.833	.040
	HACCP procedures at every step in the production process	.386	.055	.121	7.018	.000
	Storage conditions of all food	.122	.034	.034	3.588	.027
	Protection from contamination away from chemicals, physical and biological contaminants	.134	.020	.068	6.700	.000
a. Dependent Variable: food safety						

The specific model was:
Food safety $=2.229+.386X_3+.134X_5+.122X_4+.112X_1+.068X_2$
Where X_1 is Hotel food safety control aspects, $X_{2=}$ Receiving food only from approved suppliers, $X_{3=}$ HACCP procedures at every step in the production process, $X_{4=}$ Storage conditions of all food, $X_{5=}$ Protection from contamination away from chemicals, physical and biological contaminants.

Hypothesis testing for the application of food safety systems

The hypothesis was tested using the simple linear regression. The study sought to test the given null hypothesis:

$H_{o1:}$ Application of food safety standards has no significant relationship with food safety in 5-star hotels in Nairobi.

The hypothesis was tested and the acceptance/ rejection criterion was that, if the p value is greater than the significance level of 0.05, we fail to reject the Ho_1 but if it is less than 0.05 level of significance the Ho_1 is rejected.

Results indicate that the p-values for the indicators were significant ($p<0.005$). The null hypothesis was therefore rejected. The alternative hypothesis was accepted that the application of food safety standard systems has a significant relationship with food safety.

Conclusion

From the study findings, it is concluded that the application and compliance of international food safety standards to food safety systems influence the provision of safe food in hotels. In this study, the results of most of the hotels indicated and confirmed that wherever HACCP and other food safety systems functioned effectively the food served was safe, hence, validating the processes and the management practices of the food safety systems. The study found that there is a statistically significant improvement in food safety as a result of using food safety standards. The study, therefore, concluded that applying food safety systems leads to the provision of safe food in hotels.

The study found that there is a statistically significant improvement in food safety as a result of complying with food safety systems. Preventive measures among them adequate knowledge on eluding cross-contamination significantly influenced food safety and can create a positive attitude on food safety compliance. The study concluded that adhering to food safety systems leads to the provision of safe food in hotels.

The study, hence, recommended that all hotels meet the standardization requirements, especially the use of HACCP principles to ensure food safety. In addition, hotels regularly train their food handlers and ensure only health certificated workers are engaged while the government should enhance the hotel efforts by adopting a fully-fledged food safety authority that would be responsible for coordinating food safety operations to assure food safety, traceability, monitoring and reporting.

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CHAPTER SEVEN

STATE OF THE KITCHEN PHYSICAL ENVIRONMENT IN ENSURING FOOD SAFETY MANAGEMENT IN THE HOSPITALITY INDUSTRY

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Abstract

With the ever-growing world population, food safety is becoming more important as more people opt to eat out. Complying with food safety regulations is therefore important as its failure can result in the transmission of foodborne illnesses which are estimated to cause 33 million deaths annually. Food safety, therefore, needs to be applied and monitored at each stage of the food supply chain and the kitchen, being the last stage in the supply chain before the food gets to the customer (fork) is very critical in ensuring food safety. The objective of the study was to assess/ investigate the state of kitchen physical environment in ensuring food safety management in selected hotels in Eldoret town, Kenya. The study was qualitative and employed a cross-sectional descriptive research design. Eight conventional hotels in Eldoret town were purposively selected for the study. Data was collected by the use of observation checklists to assess the physical environment of the hotels in ensuring food safety. The observation checklist included an assessment on kitchen physical environment in terms of promoting four of the five keys to safer food by the World Health Organization: keep clean, temperature control (in both cooked and raw storage), cross-contamination control and thorough cooking of food. Special emphasis was put on observing the availability and the condition of equipment to help manage food safety in the facilities. The study findings revealed that only 20% of the hotels had sinks for hand washing with soap and hand driers to enable the workers to wash their hands as they work, 20% did not have separate areas for preparing different foods, more than 50% did not have proper storage temperatures and did not store raw and cooked foods separately while only 20% held foods at correct temperatures. Furthermore, none of the hotels had a probe thermometer to check the internal temperature of cooked foods. Similarly, none provided gloves for use when preparing ready to eat food items such as salads and juices. However, 90% of the hotels had good work surfaces made of stainless steel and were well lit and ventilated. This study concluded that kitchen physical environment in most of the hotels under study was found to be inadequate in ensuring food safety especially with concerns to hand washing facilities, food preparation areas, storage areas, and temperature control.

Keywords: kitchen, food safety management, Eldoret

Background

Food safety has become a critical issue facing the foodservice industry. It is a vital issue both in developed and developing countries alike given that foodborne illnesses contribute to millions of illnesses and thousands of deaths annually and is becoming a key public health priority because a large number of people take their meals outside the home. As a result, they are exposed to foodborne illnesses that originate from food stalls, restaurants and other food outlets [1]. Furthermore, public exposure to unsafe food handling practices is likely to increase as the popularity of dining out and "take out" grows [2] and therefore this consumer lifestyle emphasizes the need for better and more effective ways of controlling food hygiene [3]. Food safety remains a key public health challenge in the 21st century, both in developed and developing countries and empirical data shows that there are weaknesses in the way that food safety is managed, even in large food businesses [4].

According to [5], consumer responsibility for food safety and sanitation begins with the purchase of food and extends through many separate steps in its handling, storage, preparation and serving, as well as in the related cleanup and the care and use of leftover food. Studies done on food safety situation in food service establishments in Kenya have majorly focused on the knowledge, attitude and practice of the food handlers and very few if any have looked into the infrastructure. Most of the studies have been quantitative and, consequently, relied heavily on the reporting by the respondents. This study, therefore, was carried out to bring out the reality of exactly how things are on the ground and therefore assessed the suitability of the kitchen physical environment in ensuring food safety.

Method

This was a qualitative study that employed a cross-sectional descriptive research design. Ten conventional hotels in Eldoret town were purposively selected for the study because they are fully serviced than most of the food establishments that have been studied with regards to food safety. Data was collected by the use of an observation checklist to carry out an assessment of the kitchen physical environment of the hotels in ensuring food safety. The observation checklist included an assessment on kitchen physical environment in terms of promoting four of the five keys to safer food by the World Health Organization: keep clean, temperature control (in both cooked and raw storage), cross-contamination control and thorough cooking of food. Special emphasis was put on observing the availability and the condition of equipment to help manage food safety in the facilities. The following were the focus of the observation: physical features in terms of availability of separate sink for hand washing, disposable hand towels or presence of a hand drier, and running water with soap, availability of separate rooms for different food preparation, storage of cooked and raw foods, holding temperatures, cooking temperatures, and method of thawing frozen foods; equipment in terms of cleanliness and maintenance, suitability for use and usage i.e availability and use of thermometer to check internal temperature of cooked foods, availability and use of gloves, availability and use of different color-coded chopping boards, and availability of various storages with correct temperatures; and finally lighting and ventilation in the kitchen. The data collected was tabulated and analyzed by use of descriptive statistics (frequencies and percentages).

Findings

Only (50%) of the hotels had a separate hand washing sink out of which only two provided soap and hand drying towels/ drier. One hotel had the hand washing sink outside the building (Figure 1) while another did not have the sink completely. In two hotels, the chef's sink doubled up as the hand-washing sink as well while in another the sink for washing utensils was the same one that was used for washing hands. However, all the hotels had running water for washing the utensils although only one had a hot water tap with running hot water. Some did have the hot water tap but with cold water running while others had the hot water tap blocked and no water coming from it. This is a clear indication that it is not possible for the food handlers to keep clean since the hand washing facilities are either not there or if there, are inadequate to allow them to wash their hands sufficiently. This can be attributed to lack of knowledge by the management of the importance of hand washing when one is handling food.

Figure 7-1: Separate hand washing sink for food handlers without soap and hand drier

Table 7-1 shows the findings of temperature control where only 50% of the hotels had adequate storage facilities with thermometer temperature readings. Other hotels had freezers and refrigerators without temperature readings and so it became difficult to ensure proper storage temperatures. This may lead to food going bad and especially when the power goes off for those hotels that do not have generators. When it comes to thawing of frozen foods, five (50%) of the hotels thawed frozen foods using acceptable standards (either using cold water or putting the food to thaw overnight in the refrigerator) while others used other unacceptable means such as leaving the food on the counter overnight, putting in hot water or microwaving. However, holding temperatures were quite inadequate as only one (10%) of the hotels was observed to have held hot and cold foods at the appropriate temperatures. Storage temperatures were also observed to be inappropriate in most of the hotels. For instance, only five (50%) of the ten hotels observed had thermometers on their correct refrigerators, two (20%) had thermometers in the cold room whereas five (50%) had correct freezer temperature. Seven (70%) of the hotels had the correct temperatures for the dry goods storage. Only one (10%) hotel had a generator in case of an emergency. Additionally, none (0%) of the hotels had a probe thermometer although all of the hotels had different ways of ensuring that the internal cooking temperature of the meat was attained. This could be because of lack of management knowledge on the importance of temperature control in ensuring food safety.

Table7- 1: Temperature control as observed

Temperature control	n (%)
Probe thermometer available	0(0%)
Frozen food is thawed using acceptable methods	5(50%)
Cold foods held at appropriate temperatures <40^0F/5^0C	1(10%)
Hot foods held at appropriate temperatures >140^0F/60^0C	1(10%)
Adequate temperatures for the various storage areas:	
Refrigerator (<10^0C	5(50%)
Cold room (4-10^0C)	2(20%)
Freezer (-18^0C)	5(50%)
Dry goods store (room temperature)	7(70%)

Findings on prevention of cross-contamination control showed that only one hotel (10%) had separate rooms for preparation of the various food items (Figure 2) while most hotels (80%) had foods prepared in the same room though with designated areas for specific tasks (Figure 7-3). However, one hotel (10%) used the same table for various tasks with imaginary lines to distinguish which section should be used for various tasks (Figure 4) and one hotel (10%) did not even designate any space for different tasks but any food was prepared in any available space on the same table since different food items were prepared at different times as per the order by the customers (reported by the chef). With regards to the storage of raw and cooked foods, only two (20%) hotels stored raw and cooked foods separately (Table 7-2). Eight (80%) of the hotels stored foods using the FiFo method. However, none of the hotels provided gloves for use when preparing ready to eat food items such as salads and juices. This finding suggests that the chances of consuming contaminated foods in these hotels are high since most hotels have not put preventive measures for cross-contamination control.

Figure 7-2: Kitchen with different sections for food preparation

Figure 7-3: Kitchen with designated work areas

Figure 7-4: Kitchen with a central work surface with imaginary boundaries

Table 7-2: Prevention of cross contamination as observed

Variables	n(Percentage)
Ready to eat food and raw food are prepared separately	6(60%)
Raw foods are stored below ready to eat foods 1	1(10%)
Foods are stored in FIFO method	8(80%)
Raw and cooked foods are stored separately	2(20%)
Separate chopping boards are used	7(70%)

Other than inadequate food preparation and storage areas in most of the hotels, three (30%) of the hotels did not have appropriate working surfaces whereby work surfaces were not made of the right material (non-absorbent and inert materials–stainless steel) and in some cases, the work surfaces were joined with nails as in Figure 7-5 while others had joinery sections i.e was not continuous and had rust as shown in Figure 7-6 and some were even made of chipped formica. These could harbor pathogens because of their inability to be cleaned thoroughly thus posing a food safety threat.

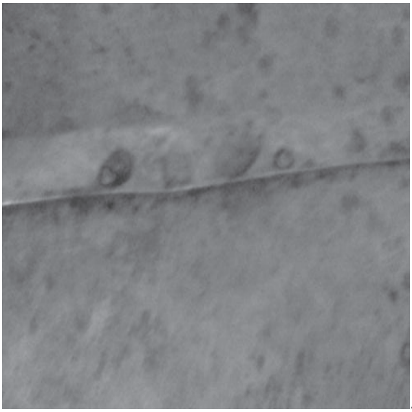.

Figure 7-5: Rusted work surface joined with nails

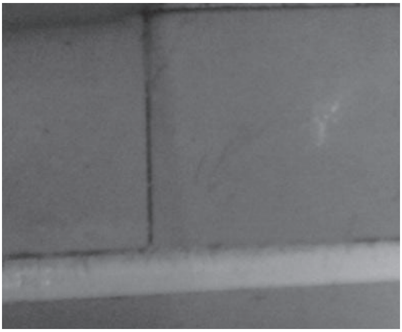

Figure 7-6: None continuous work surface

The findings also revealed that six (60%) of the hotels had separate storage for raw and cooked foods. Most of them (3 hotels) had raw foods stored together with cooked foods with some foods uncovered. Other stores had food kept together with other things like cleaning detergents and steel wool and spirit while some foods were kept on the floor and others stored food in the filing room as shown in figure 7-7. Only 1 (10%) hotel had distinct and separate areas for food storage. The rest of the hotels mixed up things, with cooked foods being stored together with raw foods in the same place either in the cold room or in the refrigerator and others not covered with some food items even being put down on the floor.

Figure 7-7: Dry goods storage

Despite the fact that 70% of the hotels under study had different color-coded chopping boards for various tasks, they were just used haphazardly depending on which one was accessible (convenience) and the manner in which they were cleaned could be a major cause of food contamination since they were not thoroughly cleaned (Figure 7-8). The most probable reason for these findings could be that most hotel owners and managers do not have food safety training and at the same time do not have training background on hospitality hence do not quite understand the needs of the industry when it comes to ensuring food safety.

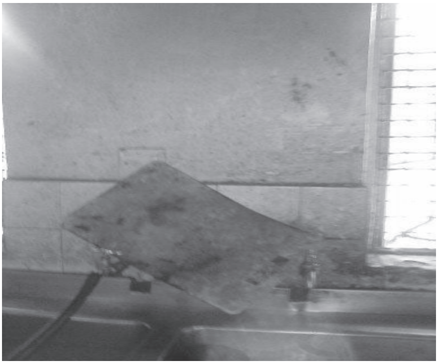

Figure 7-8: Inadequately cleaned chopping board.

Discussion

Several studies on food safety practices among food handlers have most of the time concluded that food safety practices are inadequate. Similarly, studies on the relationship between food safety knowledge and practice of food safety have not found any significant association between the two [1], [6]– [8]. Some of the factors leading to this gap have been found to be lack of basic infrastructure as well as poor knowledge of hygiene and practices in foodservice establishments [9]. Additionally, the following factors have been highlighted as impacting the food workers and managers' safe food preparation practices: time pressure; structural environments, equipment, and resource; management and co-workers' emphasis on food safety, worker characteristics, negative consequences for those who do not prepare food safely; food safety education and training; restaurant procedures; and glove and sanitizer use [10]. They argue that structural environment, equipment, and resources, availability and accessibility of adequate resources such as sinks and soap to facilitate hand washing and glove use; multiple color-coded cutting boards and separate work areas for different types of food help prevent cross-contamination; and well-maintained equipment and certain kinds of equipment including blast chillers and infrared thermometers to facilitate temperature control hinders practice of food safety. Further, not having enough workspace, however, make cooling and holding foods at proper temperatures difficult and therefore environmental/work-site barriers must be taken into consideration in order to ensure food safety behavior/ practices [7].

According to WHO, food workers need a work environment that promotes the production and preparation of safe food and further, workers, particularly in developing countries, often lack sanitary and other services like appropriate toilet and hand washing facilities that would improve the safety and quality of the foods they produce [11]. Factors that play a significant role in employees' behaviors are directly correlated with the organizational structure in the company, the level of job satisfaction, labor conditions and relations between employees and their supervisors. This means that facilities should be designed with food safety and sanitation in mind and they must comply with all relevant regulatory standards. The right equipment must be selected for the right job and employees must be provided with proper tools necessary to do their work if food safety management is to be implemented and so [12] postulate that food safety practices will only be implemented given adequate resources and appropriate management culture.

Conclusion

This study concludes that kitchen physical environment in most of the hotels under study was found to be inadequate in ensuring food safety especially with concerns to hand washing facilities, food preparation areas, storage areas, and temperature control.

Recommendation

The study recommends that, necessary measures should be put in place by the regulatory bodies to ensure that all hotels comply with the laid down regulations in the design and furnishing of hotel kitchens. The regulatory bodies should also ensure that no food establishment is licensed to operate before meeting the recommended minimum infrastructure, and equipment requirements in addition to the current requirements for TRA license for accommodation and restaurant facilities.

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CHAPTER EIGHT

FOOD SAFETY ISSUES ASSOCIATED WITH PASTORALIST MILK IN NORTHERN KENYA

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Abstract

Despite milk being an important component of pastoralist food security, the milk value chain is faced with several food safety issues. This study assessed the food safety issues along the pastoralist milk value chain in Northern Kenya. Data was collected through household interviews (n=260), focus group discussions (n=14), key informant interviews (n=14) and milk quality analysis (foreign particles, total viable counts (TVC), coliforms and antibiotic residues). The data was analyzed using descriptive statistics. About 72.3% of the households reported screening their livestock for mastitis before milking. The main mastitis screening methods were pouring on a black surface and checking for clotting (36.4%), observing physical swelling of the mammary gland of the animal (26.3%), milking on the ground and checking for blood spots and clotting (14.1%). These methods can only detect clinical mastitis. About 10% of the households consumed the mastitis milk either raw or in tea. The main types of containers used to handle milk were traditional milk containers

(80%) and plastic containers, i.e. recycled cooking oil containers (20%). Plastic containers are difficult to clean and present food safety concerns. Milk consumed in the household was of varied safety standards. Hair/ fur, sand, soil, charcoal flakes were present in 97.9% of the samples (n=47). Antibiotic residues were detected in all the samples, an indication of non-observance of withdrawal periods after administration of drugs to livestock. A third of all the analyzed milk samples had TVC and coliform counts above the Kenya standards for grade I raw milk, i.e. TVC ≤ 2 x10^5 cfu/ ml; coliforms ≤ 1.0 x10^3 cfu/ ml. Consumption of raw milk was high among the pastoralist population. These food safety issues could be addressed through capacity building on better mastitis detection methods such as the California Mastitis Test for detecting both clinical and sub-clinical mastitis pathogens; capacity building on dangers of consumption of raw milk, and hygienic milk handling, focusing on all actors in the milk value chain.

Keywords: milk, food safety, pastoralist, Kenya

Background

Milk is an important component of pastoralist food security in the arid and semi arid lands (ASALs) of northern Kenya. The main milk-producing livestock species include camel, cattle, sheep and goats. Surplus milk is sometimes sold in urban centres and the derived cash contributes to the total household cash income, which is used to purchase cereals, oil, sugar, drugs and other household requirements. Despite the important contribution of milk to ASAL inhabitants, little is known about the food safety aspects of the pastoralist milk chain. Previous studies showed that knowledge of food safety was low among value chain actors [1]. This study, therefore, aimed at identifying the food safety issues associated with pastoralist milk in northern Kenya. The paper presents data conducted in Marsabit County of northern Kenya. Understanding of these practices will help to design appropriate strategies to enhance the contribution of milk to food security for ASAL inhabitants, especially the poorer households.

Materials and methods

Study area

The study was conducted in December 2014 in Laisamis and Loiyangalani divisions of Laisamis sub-county, situated north of the Equator at coordinates 1.41 to 2.60 °N and 36.97 to 37.93°E, and altitude of 360 to 1013 m above sea level. Laisamis sub-county is located 500 km north of Nairobi (Figure 8-1).

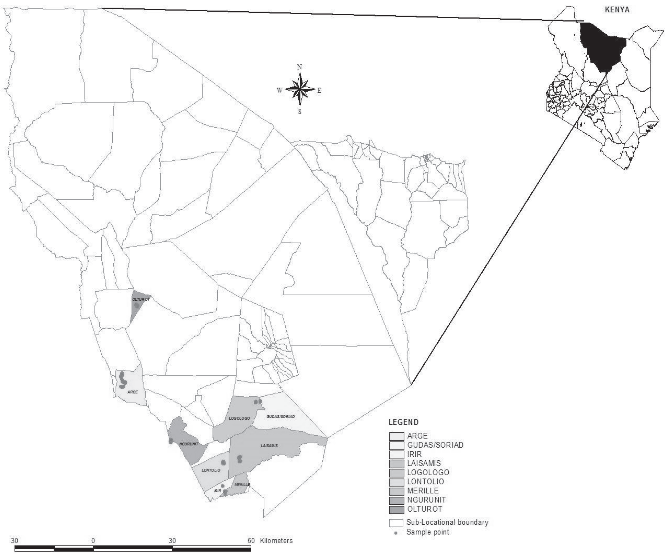

Figure 8-1: Map showing the study area

The climate is arid, characterized by low erratic rainfall (413 mm rainfall annually), high temperatures (25°C average annual temperature) and desert adaptive vegetation. Laisamis sub-county has an area of 20,290 km^2 [2] and is sparsely populated with an estimated population of 72,600 with 20% of them being children under 5 years of age [3]. The Laisamis community consists mainly of Rendille, Samburu and Aarial pastoralists who rely on livestock (camels, cattle, goats and sheep) as the main source of livelihood.

Experimental design

Laisamis division acted as the experimental site and Loiyangalani division as the control sites. The sample size was calculated to be 260 (130 in each site). These sample sizes are within the range recommended by [4] for dairy products consumption surveys. Data was collected using household interviews (n=260), focus group discussions (n=14), key informant interviews (n=14) and milk quality analysis (foreign particles, total viable counts (TVC), coliforms and antibiotic residues). Quantitative data from the household interviews was triangulated through FGDs, key informant interviews, participant observation and secondary data.

Key informant interviews

Key informant interviews (KII) were carried out with persons strategically placed to possess vital perspectives on livestock husbandry, milk production, household use, value addition, marketing, and child nutrition. Respondents for KII were purposively selected and included extension officers, village guides, local leaders (chiefs and village elders), dairy group representatives, livestock keepers, and elderly people (grandparents) from the community.

Focus group discussions

Focus group discussions (FGDs) were conducted in groups of 8 to 12 respondents in the selected target areas to obtain community views regarding milk production and access, milk handling, processing and value addition, household milk consumption, milk and milk products selling. Individuals selected for the FGDs were those knowledgeable on the subject under study so as to have maximum information and were purposively selected with the assistance of key informants (community leaders, village guides, etc.). The participants were stratified into homogenous groups as listed below, for purposes of ensuring an environment that enabled optimum participation, i.e. (i) mothers/ caretakers of children 6-59 months old, and (ii) grandmothers.

Milk quality analysis

Fourty-seven milk samples, each from experiment and control households, were analyzed on-site for milk quality platform tests—colour, smell, presence of foreign particles, clot-on-boing and alcohol test. A further 21 samples (11 from experiment and 10 from control households) were collected into sterile 50 ml labeled Falcon tubes, kept in an ice-box (4 °C) and transported within 8 hours to a laboratory in Nairobi for immediate analysis (total viable count, total coliforms and antibiotic residues). Both platform and laboratory tests followed standard procedures [5].

Personal observations

Personal observations were made to fill the gap that might have not been captured during the interviews, particularly to describe some of the routine daily activities practiced by households and traders. Sites visited and observed included households, grazing areas, livestock milking, and watering points. Specifically, an observation was noted on the level of hygiene and sanitation practices associated with milk handling.

Data analysis

Characteristics of the households were described using descriptive statistics (frequencies, means, totals, percentages and measures of dispersion); continuous and categorical variables being reported as mean ± standard errors and percent, respectively. Data analysis was done in SPSS Statistics Version 20 (IBM Corporation, SPSS Statistics Release 20.0.0; USA). Qualitative data from FGDs, KIIs and participant observations were summarized into themes and written into descriptive prose.

Result and discussion

Milk-producing livestock kept

All households kept milk-producing livestock (except one household in the experiment site). The livestock kept were camels, cattle, sheep and goats, all of indigenous breeds (Table 8-4).

Table 8-4: Milk animals kept by pastoralist in Laisamis sub-county

Species	Breed
Camels	Mainly Rendille breeds; and a few Somali breeds especially around Ngurunit
Cattle	Mainly Boran breed; and some crosses of Boran and Zebu
Goats	Mainly Small East African, and Galla goats
Sheep	Back Head Persian

Mastitis screening before milking

The milk-producing livestock kept included camels, cattle, goats and sheep. About 72.3% of the households reported screening the animals for mastitis before milking. The main mastitis screening methods were pouring on a black surface and checking for clotting (36.4%), observing physical swelling of the mammary gland of the animal (26.3%), milking on the ground and checking for blood spots and clotting (14.1%) (Table 5).

Table 8-5: Mastitis screening methods by households in Laisamis sub-county, Kenya

Mastitis screening method	N*	Percent (%)
Pour milk on a black surface and check for clotting	36	36.4
Observe physical swelling of the mammary gland / animal teat	26	26.3
Milk on the ground and check for clotting	20	20.2
Milk on the ground and check for blood spots in the milk	14	14.1
Observe blockage of the milk flow from the teat during milking	2	2.0
Use strip cup	1	1.0
Boiling the milk and checking for precipitation	0	0.0
Total	99	100.0

*N indicates the number of households that responded

Other methods of mastitis screening as reported from FGDs included:

- Checking stiffness of the teats during milking. Teat with mastitis will be hard/ stiff.
- The cow runs away from the calf when the calf is about to suckle (because the teats are painful).
- Animal with mastitis will produce less milk when milked.
- Tasting the milk; mastitis milk will be bitter.

These methods can only detect clinical mastitis which is one of the most economically significant diseases affecting milk quality.

Milk containers

The main types of containers used to handle milk were traditional milk containers followed by plastic containers (Figure 8-2). There are many differently shaped traditional milk containers (Figure 8-3), each of which serves a specific function. For example:

- Camels are milked in *mbasige* (u-shaped woven bowl),
- Cattle, goats and sheep are milked in *soror*, *ngoiting*, *ngilip*, and *sanderi*,
- *Ngilip* is used for storage of milk, and also churning to make butter),
- *Naitu* is used for the storage of camel milk from *mbasige* for older women, and also milking cattle.

Milk container shape is a complex area deserving an entirely separate paper.

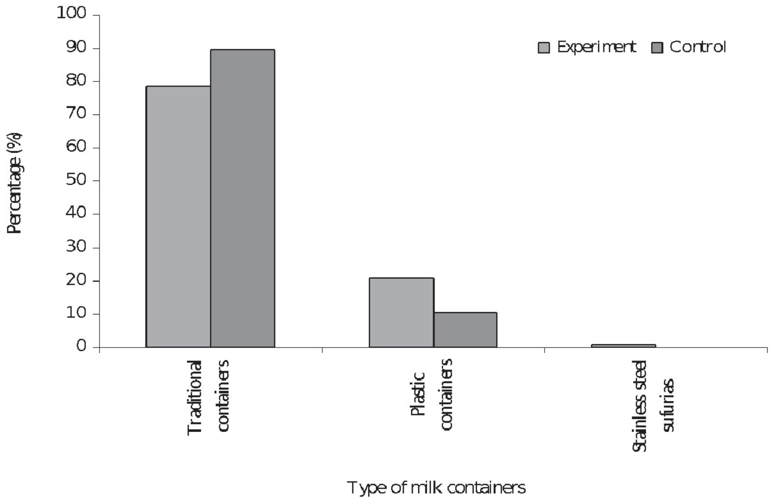

Figure 8-2: Milk containers used in Laisamis sub-county, Kenya

Figure 8-3: Traditional milk containers, from left to right: Ngilip *(for milk storage and churning),* Naitu *(for storage of camel milk from* mbasige*),* Naitu *(for milking cattle),* soror *for milking cattle, sheep and goats,* ngoiting *(for milking cattle, sheep and goats);* and mbasige *(u-shaped bowl, for milking camels).* (Picture by F.O. Wayua)

Quality of milk consumed in the households

Foreign particles were present in 97.9% of the samples in each site and included hair/ fur, charcoal flakes and sand/ soil (Table 8-6). Qualitative data obtained from FGDs and KIIs indicated non-observance of withdrawal periods by all respondents after the administration of drugs to livestock, implying the presence of antibiotic residues in milk of such animals. However, laboratory analysis revealed that antibiotic residues were not detected in all the 21 milk samples analyzed (n=11 experiment and n=10 control). Besides the small sample size for laboratory analysis, this is more a likelihood of limited or no use of veterinary drugs by the pastoralists, where deworming, vaccination, disease and parasite control were practiced by only 15 to 23% of the households in both sites. Nonetheless, a third of all the analyzed milk samples in each site had total viable counts (TVC) and coliform counts above the Kenya Standards for grade I raw milk, i.e. TVC $\leq 2 \times 10^5$ cfu/ ml and coliforms $\leq 1.0 \times 10^3$ cfu/ ml [6] (Table 8-6, Figure 8-4 and 8-5). Total viable counts estimate the microbial population of raw milk (inclusive of mastitis pathogens), whereas coliforms are indicative of the hygiene of the milking environment and post-milking contamination [5].

More samples from experimental households (12.8%) failed the clot-on-boiling and alcohol test (Table 8-6), an indication that they had started fermenting. This is related to the time interval between milking and sampling. All samples were morning milk collected on the same day—experimental samples approximately five hours after milking and being stored at ambient temperatures. The various tests show the importance of having multiple indicators for milk quality. Based on the milk quality parameters tested, the overall quality of the rest of the milk samples can be termed as good. For human consumption, the milk should be sieved to remove the foreign particles, and boiled to eliminate microorganisms.

Table 8-6: Quality of milk consumed in the households in Laisamis sub-county, Kenya

Continuous variables	**Category`**	**Mean (n=10)***
Total viable counts (TVC)	Passed (x 10^5 cfu/ml)**	1.1 (7)***
	Failed (x 10^7 cfu/ml)	15 (4)
Coliform counts	Passed (x 10^3cfu/ml)	1.1 (7)
	Failed (x 10^5 cfu/ml)	40 (4)
Categorical variables	**Category**	**Percent (n=47)**
Smell of milk	Smoky smell	97.9
	Slightly sour	2.1
Colour of milk	Opaque white	93.6
	Creamy	6.4
Foreign particles	Present	97.9
Type of foreign particles	Hair/ fur	48.9
	Charcoal flakes	21.3
	Sand/soil	19.1
	Mixture of sand, hair, charcoal	8.5
Clot on boiling	Positive	12.8
Alcohol test	Positive	12.8

Nevertheless, capacity building will be needed on how to eliminate the foreign particles and on the storage of milk in the households. Even though the sample sizes are too small for conclusive statistical inferences, they give a general picture of the quality of milk consumed in the pastoral households in northern Kenya. More conclusive status of the milk quality could be obtained by analyzing more milk samples.

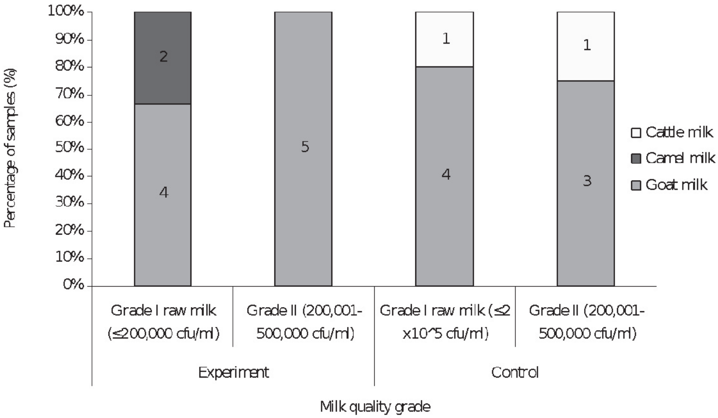

Figure 8-4: Total Viable Counts in milk consumed in households in Laisamis sub-county, Kenya

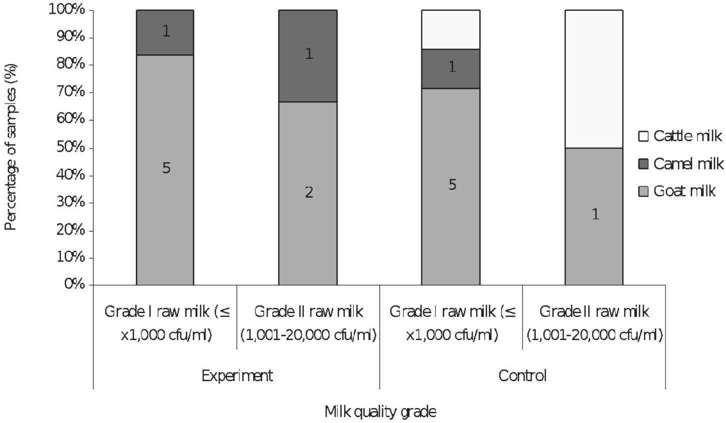

Figure 8-5: Coliform counts in milk consumed in households in Laisamis sub-county, Kenya

Conclusion and recommendation

This study shows that the pastoral milk chain in northern Kenya is characterized by food safety issues of significant public health concern. These food safety issues could be addressed through capacity building on better mastitis detection methods such as the California Mastitis Test for detecting both clinical and sub-clinical mastitis pathogens; capacity building on dangers of consumption of raw milk, and hygienic postharvest milk handling, focusing on all actors in the milk value chain. Low-cost processing and value addition technologies could also be promoted to enhance the safety and quality of marketed milk.

Acknowledgement

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CHAPTER NINE

FOOD SECURITY AND FOOD SAFETY IN KENYA: THE ROLE OF UNIVERSITIES

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Abstract

Food insecurity is a prevalent problem affecting 40% of the Kenyan population. As of March 2019, thirteen counties in Kenya were facing starvation due to the problem of drought. Children under five are especially vulnerable to malnutrition as 26% of the children are stunted, 11% are underweight and 6% are wasted. Hidden hunger further afflicts over 50 percent of children in spite of the various intervention programmes. The causes of food insecurity are poverty, drought and poor agricultural systems that lead to food losses and contaminations throughout the food value chain. Many Kenyan do experience the problem of the four food dimensions namely; accessibility, availability, utility and sustainability. Food safety is a major challenge to poor food utility and this problem is exacerbated by poor access to water, contamination of water, poor hygiene, poor waste disposal facilities and simply lack of knowledge. This has resulted in waterborne diseases, diarrheal diseases and other complications leading to diseases such as cancer. To mitigate these problems, universities in Kenya have mounted programmes in agriculture, occupational health, public health and nutrition that aim to build capacity to tackle these challenges, the formulation and implementation of the public health act to reduce these incidence, development of relevant material in the promotion of food security and maintaining of public health

promotion for the Kenyan population, generating innovations in the area of food security and food safety, research and monitoring and evaluation of food security and food safety systems. However, gaps that exist in universities in playing their role are; lack or limited modern state of the art equipment to carry out research, translating research into policy and political will for advocacy programmes. Further collaboration among stakeholder namely universities, relevant ministries and the food regulatory body is missing and unless this link is strengthened Kenyan will continue to suffer the problem of food safety.

Keywords: food security, food safety, health promotion, malnutrition and hidden hunger.

Background

In Africa close to 72 million people suffer from acute hunger according to the FAO 2018 report. Food insecurity is a prevalent problem affecting 40% of the Kenyan population. As of April 2019, 13 counties in Kenya were facing starvation due to the problem of drought. Children under five, the elderly and women in their productive age groups are especially vulnerable to hunger and malnutrition. According to the Kenya Demographic Health Survey, 2014 [1], 26% of the Kenyan children were reported stunted, 11% underweight and 6% wasted. Hidden hunger afflicts over 50% of the children in spite of various interventions. According to KNBS [2] two counties namely, Turkana and Baringo reported acute food insecurity (Table 9-1).

In countries on the verge of famine like Kenya, up to 80% of the population depends on rain-fed agriculture and hence need humanitarian food aid and measures to help boost agriculture. There are many causes of food insecurity but the major ones include: low access to fertile lands and production resources has been a major cause of food insecurity which is inherited from one generation to another in spite of population swelling. Post-harvest losses include harvesting when food has a high moisture content, poor storage, packaging, transport, processing and lack of markets for harvested foods [3]. According to KNBS, 1.9 million tonnes of food is lost annually and maize is the most affected with an average loss of Ksh29.6 billion worth of crop wasted followed by green bananas at a loss of Ksh24 billion (Table 9-2).

Table 9-1: County food insecurity score

County	% Food Secure	% Low food insecure	Chronic Food insecure
Taita Taveta	74	20	6
Baringo	75.4	16.1	8.5
Bomet	83.7	14.8	1.5
Bungoma	65.4	30.8	3.8
Kiambu	84.2	15.3	0.05
Turkana	23.4	37.3	39.2
Makueni	66.5	26.1	7.3

Source: KNBS 2015 [2]

Table 9-2: Post-harvest losses of food in Kenya (2018)

Food affected	Amount of losses in Kshs (Billions)
Maize	29.6
Green bananas	24
Irish potatoes	19.7
Milk	12.4
Beans	11.5
Ripe bananas	5.6
Sweet potatoes	2.4
Pineapples	2.4
Sorghum	1.9
Millet	1.6

Source: Economic Survey, 2018

A study of the Irish potato losses in Kieni East, reported that food losses in the Irish potatoes accounted for 50% loss and losses were majorly due storage, transportation and market conditions [4]. In fact, during storage farmers reported up to 50 percent losses. In April 2019, KALRO held an international conference in Nairobi to showcase innovations and management practices in sustainable land and water use and pre and post-harvest value addition technologies for improved local and global competitiveness. I do hope this will impact positively on the end-users of these innovations.

Climate change: The devastating effects of climate change coupled with rainfall patterns have resulted in food insecurity in North Eastern counties of Kitui, Garissa, Isiolo, Wajir, Marsabit and Machakos. In these counties, maize crop is no longer a staple food crop as the weather cannot sustain it [5]. Drought and floods affect food production, post-harvest losses and food safety in equal measure. Flood additionally damage the infrastructure used during the value chain. A good example is the road network used to access the market and storage facilities [6]. Climate change-induced floods are thus a danger that threatens to greatly undermine food security not only through climate change agriculture productivity but also increase post-harvest losses [7]. Small scale farmers are particularly vulnerable to weather variability with multiple stresses occurring at many levels, thus limiting their adaptive capacity. To deal with this problem of climate change the agricultural sector has continuously adopted strategies such as the use of new crops, crop diversification, adaptation of mixed crops and livestock farming, changing planting dates and adaptation of irrigation [8].

Bacterial and fungal spoilage of the crops greatly affect food security. Spoilage may not only reduce income and food security but also result in severe negative impacts such as aflatoxins in maize that cause cancer. Death as a result of aflatoxins in maize crop has previously been reported in Machakos County.

Insects and rodents' outbreak are also expected to cause damage to the crop thus resulting in food insecurity. During the year 2018/ 2019, the outbreak of armyworms in Kenya wiped out maize farms in the food basket areas and Western Kenya resulting in food insecurity [5]. As a result of this, some counties such as Bomet have now shifted to the growing of avacado instead of the maize crop.

Poor access to financing is a major challenge to food security. Risks associated with agribusiness coupled with complications in land laws and tenure systems limit the use of land as collateral for agricultural activities [9]. In Kenya many of the small scale farmers are women and yet they do not own land. This thus limits them from accessing the finances to aid them in agricultural activities.

Poor extension services; Over the years Kenya has relied on public agriculture services coordinated centrally. Currently, agricultural services have been decentralized and allocated limited budget since 2013, hence the effectiveness of extension services has been reduced thus calling for the reorganization of the public sector agricultural services. Further, the link between national extension services and county extension services is weak [10]. Poor or limited agriculture market information system: currently data gathering and dissemination on agriculture market systems in Kenya is poorly fragmented and limited. Most agriculture information systems have tended to rely overly on extension support and therefore remain unsustainable. Besides, the messages disseminated do not necessarily focus on post-harvest losses at the different stages of the food supply chain.

Limited research on the food system value chain exists despite the high number of skilled scientists engaged in agricultural research at both private and public universities. Currently, no mechanism exists to harness this strength at the national level. Further, research that is carried out is not timely disseminated to the farmers. In addition, findings at various levels along the value chain are limited. Waudo reported these gaps among farmers [4]. The fact remains that farmers are not updated on the latest agriculture innovation and this tends to limit their performance. For example, among the Irish potato farmers in Nyeri County, many did farm but lacked knowledge on how to determine the profitability of their farming ventures. In other words, they grew certain crops simply because their neighbours were growing those crops.

Strategies to improve food security

An investment in the development of the Hola and Kolana irrigation schemes in Tana River has not borne fruits because of corruption. Further, billions of money has been invested in irrigation schemes along River Turkwel and River Keiyo but with little impact. Other interventions targeting the hungry have included the following: enhancing food supply to the most vulnerable by provision of food ratios, improving rural food provision especially to small-scale farmers through provision of free seeds and fertilizer, investing in rural infrastructure by proving road networks, investing in building of rural markets to enhance access to foods, an initiative that has been taken up by all the 47 counties, revitalization of livestock by restocking wiped out stocks to enable pastoralist earn a living, resource mobilization and conservation through efforts such as reforestation and through enforcing income and other entitlement to food [9].

As seen from the above efforts, the problem of hunger persists. Part of the problem is corruption as highlighted in the media recently. Secondly, isolation of the Kenyan agriculture experts to deal objectively with this problem is a hindrance to the attainment of food security. Thirdly the lack of devolvement of research to counties the way the extension services have been devolved is proving to be an obstacle to food security. Fourthly the non-involvement of research experts from the universities and agricultural research has contributed to this problem of food insecurity.

Food safety

Food contamination is a situation where over ten parts per billion of poisonous substances are detected in a food or a drink. Foodborne infection currently called food poisoning is a public health problem in Kenya. Unfortunately, many cases go undetected as people prefer self-diagnosis and treatment or wait to recover from it naturally. In Kenya, the problem of food contamination does run through the food value chain from seeds to the plate. Cholera, aflatoxin poisoning, diarrhoea, typhoid *Salmonella* and *E. coli* are the most common foodborne diseases in Kenya. According to the Ministry of Agriculture 2018, 2% of maize in Kenya is affected by aflatoxin. Besides maize, aflatoxins affect wheat, barley, peanuts and sorghum [5]. Other sources of food contaminations are harmful bacteria. Aflatoxin is a major concern in Kenya especially with regards to food security as it leads to morbidity, hunger and mortality. For example, in 2013, the Hola agricultural scheme lost a major part of its harvest to aflatoxin. In maize, both the flowering stage and the post-harvest practices such as transport and storage have been blamed for contamination. Kenya is thus one of the hotspot countries in Africa with aflatoxins, especially in the dry areas. In the recent past, there have been reports in Machakos County in Kenya of death as a result of aflatoxin poisoning. This means that as Kenya moves to the next level of turning drylands into farms, tackling aflatoxins should be given priority [11].

Recent reports in Kenyan media have shown that peanut butter had excess aflatoxin, 24 parts per billion instead of the recommended ten or fewer parts per billion. This is a serious problem considering that many of the small-scale peanut farmers are engaged in processing this product for the market without subjecting it to testing. Meaning, therefore, Kenyans may be indeed consuming contaminated products. To stem the problem of aflatoxins, experts advise farmers to start containing poison when growing, harvesting and storing the product. Simply keeping the moisture content low will reduce afflation contamination.

In addition to aflatoxins, cholera claims between 21,000 and 143,000 lives annually yet this is one of the diseases that can be prevented easily. In April 2019, 114 cases of cholera were reported in Nairobi alone. Cholera is a bacterial disease spread through contaminated water or food. The causes of cholera are poor water access, untreated water, poor hygiene, poor waste disposal, use of raw animal and human manure and simply lack of knowledge. In 2018, according to the Nairobi waste flow report, 60% of Nairobians were reported to have no connection to the sewer line and only 34% had water that was treated. About 66% of the human waste went directly to Nairobi River, a situation that explains the many cases of cholera in Nairobi.

The use of raw human waste and animal manure is another cause of foodborne illnesses. The use of manure that is not treated to grow plants such as vegetables leads to the transmission of diseases causing germs called pathogens from animals to people and of particular concern are two bacteria called *Escherchia coli* (E-coli) and *Salmonella*. These two pathogens are found in the intestines of cattle, sheep, goats and chicken. Of one particular dangerous type of E-coli medically called 0157; H7 is a big threat to food safety and human health. These bacteria usually live in the intestines of farm animals without causing disease. However, when they get into people through food and water, they lead to severe infection. Affected individuals usually have bloody stool, diarrhoea, abnormal crumps and bloody urine and can die in severe cases. Foods mainly associated with this kind of poisoning are vegetables and fruits like lettuce, spinach and strawberry. They are usually contaminated due to their closeness to the soil. Use of raw animal manure from an animal hosting the bacteria may easily contaminate food crops with the germ. Vegetables sustain the pathogen up to the time of consumption because they are the fast-growing crops. Also, their mode of post-harvest storage and processing favours the multiplication of the germs if precautions are not taken. To complicate matters, vegetables and fruits are usually served is raw salads or in cold meal starters.

Lack of toilet facilities in the Lake Victoria regions has been reported as a source of diarrhoeal diseases and cholera. Recent reports show that people defecate in the lake as well as use the water from the lake for drinking. This is a worring trend considering that fish harvested from Lake Victoria is consumed by a wide population from all over Kenya. The lethal combination of water scarcity, corruption and the sheer lack of leadership are some of the causes of foodborne illnesses.

Strategies to tackle Kenya's cyclic hunger and food contamination

As the population grows and with rising demand for food, there is need to formulate strict food safety laws. Such laws must diligently be enforced. Failure to enforce them is the reason Kenya is struggling with preventable problems like typhoid, cholera and *E. coli*. To reduce food contamination, the government needs to reduce post-harvest losses through the provision of appropriate technologies, waive duty on cereal drying equipment, hematic bags, grown cocoons or silos. Further, both the national and county governments need to use Alfa safe to reduce these losses through establishment of early warning systems in counties since they are at the grassroots level. Enhancement of the Kenya Livestock insurance programme (KPLP) to curb animal diseases that arise as a result of on-going drought is also a viable option. This program supports pastoralist farmers to buy animal feeds, medicine and water to prevent livestock from dying and act as a source of livelihood, invest in the youth to engage in agriculture by mentoring a new generation of food producers through funding and capacity building of appropriate easy to use technologies. Better management of established irrigation schemes is needed to solve the perennial hunger problem.

The role of universities in tackling food insecurity and food contamination

Universities are known worldwide for being creators of knowledge and innovations. However currently universities have not been playing that role for the following reasons: the link between universities, the Ministry of Agriculture and the farmer is weak; and the national budget for funding university research is low and not easily accessible. The research done is not easily disseminated to the end-user and the courses that focus on agriculture and food safety are limited. For example, at Kenyatta University, School of Agriculture only 12 courses focus on Agriculture while in the department of Food, Nutrition and Dietetics only 3 courses focus on food security and food safety. This means that there is a lot of weakness in the curriculum in relation to food security and food safety. For example in the School of Agriculture the following courses are offered in food security: a) Introduction to Food Industry, b)Agricultural Marketing, c)Food Security and Trade, d) Food Marketing and Sales Management, e) Principles of Crop Production, f) Principles of Animal Production, g) Principles of Conservation and Organic Agriculture, h)

Introduction to Crop Production, i) Value addition of Farm Products, j) Post-harvest Technologies, l) Agricultural Extension and Rural Development, l) Paste and Pathogen of Stored Products.

While in nutrition only three courses are offered namely: Introduction to Microbiology, Hygiene, Legislation and Food safety; and Introduction to Food and Nutrition Security. Additionaly, these teaching programmes do not put much focus on agriculture of food safety practical application. During the past three years, there has been mass failure in Kenya Certificate of Secondary Education, especially in Biology and Mathematics thus hindering the uptake of agriculture-related courses at the university level. For example, in the year 2018 only 98,219 candidates out of 653,549 scored a C+ and above while in Biology a meager 1,503 out of 545,014 scored a C+ and above. In 2017 KCSE results show a shocking 90% of the students scored below a C+ in Biology and 95% scored below the C+ in the same subject in 2018. During the 2019 University intake, agriculture and science-based subjects have not attracted students making the future of agriculture bleak.

Agriculture as a subject has not been positively accepted as a career for the youth. There is an urgent need for a complete reorientation of agriculture as a subject to attract students. Otherwise, the country will not have farmers in the next generation.

Conclusion

- Food insecurity has been a perennial problem in Kenya since independence and yet despite many interventions the country still experiences hunger year in year out.

- The problem of foodborne illnesses is on the rise because of poor sanitation, the use of untreated water and limited waste disposal/ drainage systems.

- Universities are critical players in the enhancement of food security and safety in terms of research and creation of innovations to improve the agricultural sector.

- There is need to reorient the country in terms of the perception of agriculture as a subject and as a profession to improve uptake by the youth.

Recommendation for food safety

Farmers and consumers need to understand the relationship between food production methods and foodborne infections to avoid contamination, as the population grows with rising demand for foods, especially streets food. There is need to formulate strict food safety roles and regulate the same strictly. Kenya needs to strengthen its health systems so that it can respond to potential cholera, typhoid and *E. coli* outbreaks. The country needs to improve infrastructure to prevent health disasters and preparedness in response to disease outbreaks and this includes failure to trace people who have the disease.

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Chapter Ten

Who Cares? Consumer Attitudes and Purchase Decisions on Peri-Urban Agricultural Commodities in the Absence of Information Asymmetry

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Abstract

Production of urban and peri-urban agricultural products is gaining popularity especially in densely populated urban centers such as Nairobi City. However, effective demand for such commodities may be low due to consumer attitudes related to food safety. Further, in most cases, consumers make purchase decisions under information asymmetric conditions regarding the source of the vegetables they normally purchase. The current study sought to assess consumer attitudes towards the vegetables produced in urban and peri-urban (UPA) agricultural systems. Further, the study assessed how the elimination of information asymmetry affects consumer decisions and the determinants of the premium or discount values that consumers are willing to pay on urban and peri-urban commodities once full information is disclosed. The study applied

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exploratory factor analysis and a double hurdle model to data collected from 300 consumers in 5 regions of Nairobi City. Consumers expressed general acceptability of the use of treated wastewater for agricultural production a factor that may improve the acceptability of urban and peri-urban agricultural products. However, due to overriding food safety concerns, when given an opportunity to choose between products produced within UPA regions and those from rural areas, they would prefer the latter. Disclosure of the information on the production of vegetables using treated wastewater is likely to impact the UPA market negatively. After disclosure, the UPA market is likely to lose older consumers, employed and earning higher incomes. This might not be a problem in the short run, given that the Nairobi City has a larger population in the segment that seems to support the UPA market: the jobless and low-income consumers. However, as the city develops and the purchase of vegetables gets streamlined into formal outlets, then the market for UPA products will get thinner. Better UPA production methods must evolve and efficient wastewater treatment technologies developed as well as consumer education on the safety of wastewater treatment.

Key words: urban and peri-urban agriculture, consumer perceptions, information asymmetry.

Background

Nairobi City is home to over 2 million people, who provide a substantial demand for fresh foodstuffs given their high frequency of consuming fresh fruits and vegetables [1]. According to [2], approximately 27% of household budgets are spent on fresh vegetables. Although most of the vegetables consumed in the city are produced in rural farms close to the city, a substantial percentage of these products are sourced from producers within and around the city. Urban and peri-urban agriculture has over the years gained importance among the urban dwellers as a source of livelihoods and indeed a development tool [3], [4]. In Nairobi, urban and peri-urban agriculture is carried out in four distinct farming systems: small scale subsistence system, small scale commercial system, small scale crop-livestock integrated system and large scale commercial system [5]. Peri-urban agriculture provides urban dwellers with cheap foodstuff especially vegetables and staple cereals and therefore can contribute to their health, especially because leafy vegetables are rich in vitamins [6]. Peri-urban products are likely to be sold at lower prices because the cost of transport and inputs is much lower, given the proximity of the production points to the urban center. Production of urban and peri-urban products utilizes a diversity of water sources which include fresh water from boreholes, rivers and wells and wastewater. Even where river water is used, chances are that it is usually contaminated with waste and storm water. In most urban areas, separation of wastewater and storm water is challenging and wastewater is rarely treated [7]. Nevertheless, the collection and re-use of wastewater in urban areas can be potentially beneficial when used for agricultural production [8]. Domestic wastewater has multiple economic benefits due to the possibility to solve water scarcity in water-stressed regions and the provision of irrigation water that is rich in nutrients, reducing the amounts of fertilizers used by farmers [7]. Despite the importance, there are risks associated with the use of wastewater in urban agriculture due to the potential risk of pathogen transfer and contamination of foodstuffs. Agricultural production using untreated wastewater exposes consumers to health risks through the transmission of waterborne diseases [9]. Although wastewater treatment is one way of reducing these risks, consumer perceptions on the use of wastewater to produce foodstuff may be hard to change even when the safety of treated wastewater is guaranteed. Due to this, the peri-urban producers and sellers of their products are usually hesitant to disclose the source of their products. In most cases, however, consumers are usually not aware of the source of the vegetables they buy and even more remotely on the source of water used to grow the vegetables they buy [9]. Although the vegetables originating from urban and peri-urban systems end up in urban retail outlets and vegetable vendors, consumers may not be aware of the source of vegetables that they purchase. Given that most vegetable markets in urban areas are characterized by lack of proper standardization, labeling and packaging, it is difficult for consumers to access proper information on the sources of the vegetables they buy. Consequently, consumers make purchase decisions under situations of information asymmetry. Availing a reasonable amount of information can guide the consumers in making critical decisions [10]. The consumer decision-making process goes through five interlinked stages: information search, evaluations of alternatives, purchase and post-purchase behavior. In the absence of complete information, consumers make decisions based on the available information, however limited it may be. However, consumer decisions may be reviewed as new information emerges. The attitudes and purchase and consumption decisions are likely to be influenced greatly by access to information. As consumers get increasingly concerned about the quality of the products they purchase and the production methods, lobbying against products produced using un-hygienic methods such as the use of untreated wastewater may rise. Against this backdrop, the current study was guided by three research questions: 1. What are the consumption patterns of urban and peri-urban agricultural products and perceptions on peri-urban agriculture among the consumers in Nairobi City? 2. How does the availability of information on the type of water used in the production of vegetables influence consumer purchase decisions? 3. What influences the premium for agricultural commodities produced using treated wastewater?

Methodology

Study sites, data types and sampling methods

Data used in the study were collected using household surveys conducted among 300 Peri-urban households located in five zones within Nairobi City: Juja/Ruiru, Njiru/Ruai, Athi-River, Ngong/Kiserian and Waithaka/Kawangware. Stratified random sampling was used to identify the households that participated in the survey. The strata composed of where farming took place: within own compound or along river banks. The first category consisted of households who had established gardens within their compounds. The second cluster consisted of farmers who engaged in farming along river banks within their neighborhoods. The main rivers where farming was taking place included Thiririka, Ruiru River, Athi River, Njiru River and Nairobi River. Athi River originates from the Ngong Hills and passes through the heavily industrialized Athi-River township about 25 Km from Nairobi City Center. The river banks are awash with informal settlements which load the river with solid and municipal waste before joining other Rivers further downstream and draining into the Indian Ocean. The Thiririka River is a tributary of Athi River which originates from the Eastern slopes of the Aberdare Mountains and passes through the rapidly urbanizing peri-urban township of Juja about 25 kms from Nairobi City along the Nairobi-Thika highway.

Most of the rivers described here receive a substantial flow of storm water originating from urban and some unsettled landscapes around the city. Figure 1 shows the location of the study areas. Within each stratum, a sampling frame was developed with the help of local administrators after which a random sample was drawn from each region proportional to size.

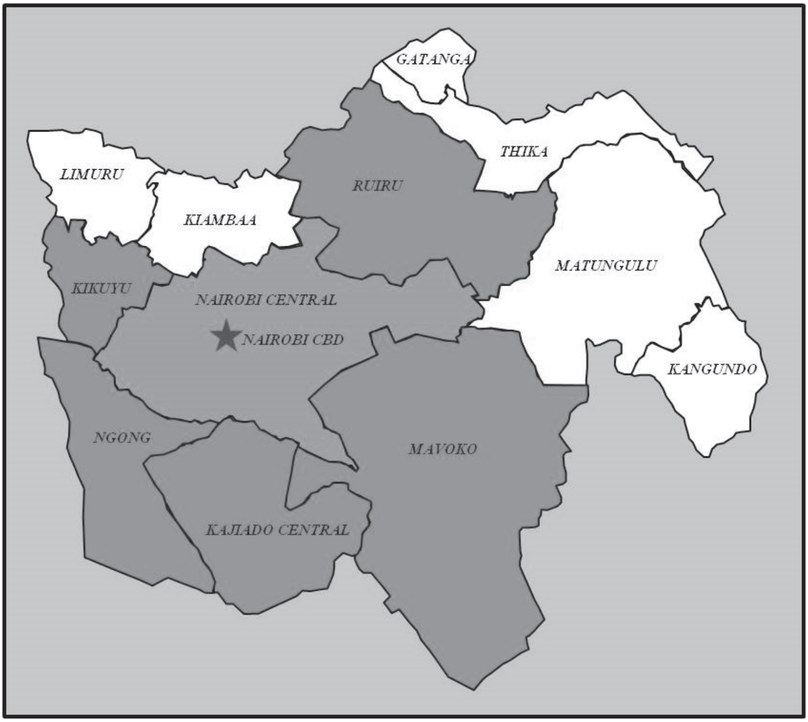


Figure 10-1: Map of Study area

Theoretical and conceptual framework

The consumer decision-making process is usually anchored in the random utility theory (RUT). A rational consumer is expected to make choices which advance their objective of utility maximization while considering the attributes of the commodity in question. The random utility theory postulates that the overall utility U derived from a commodity can be expressed as a systematic (deterministic) component V_{ij} that is a function of the attributes of a commodity and a random (stochastic) component ε_{ij}. If a rational individual i is presented with options j and k which belong to the choice set C, he/she will choose option j, over k if $U_{ij} > U_{ik}$. Analogously, the probability (Π) of choosing j is equivalent to the probability that the utility gained from its choice is greater than or equal to the utility of choosing the alternative in the choice set. Therefore,

$$\Pi_{ji} = Prob\{V_{ji} + \varepsilon_{ji} \geq V_{ki} + \varepsilon_{ki}; j \neq k, \forall \in C\} \ldots\ldots(1)$$

In the current study, we have two options in set C (vegetables produced using untreated wastewater or water of unknown quality and those treated using treated wastewater). In that case, a conditional logit model [11] can be used to model the consumer choices and estimate the probabilities given that the random terms are assumed to be independently distributed. The attributes associated with each alternative can be substituted into the deterministic part of the utility (V_{ji} or V_{ki}) and select a linear form that allows the choice probabilities take the form:

$$\Pi_j = \frac{\exp(\mu\beta X_j)}{\sum_{k \epsilon C} \exp(\mu\beta X_k)} \quad \ldots\ldots\ldots\ldots\ldots\ldots(2)$$

Where μ is a scale parameter is equal to 1, X is a vector of explanatory variables and β is a vector of parameters to be estimated and are not individual specific. The utility function can be expressed as: $V_{ji} = \beta X_i + \varepsilon_{ij}$.

Analytical framework

The current study utilized a combination of descriptive analysis, explorative factor analysis and a Double Hurdle (DH) regression model to achieve the stipulated objectives. Descriptive statistics were used to describe the sample in terms of socioeconomic characteristics and vegetable purchase and consumption trends. To assess the consumer attitudes on urban and peri-urban_vegetables, explorative factor analysis utilizing Principal Components Analysis (PCA) was conducted on 13 Likert scale items [12]. The 13 items were expected to capture the tree components of the attitude object: affective, cognitive and behavioral [13]. The affective component deals with people's feelings about the attitude object. The cognitive aspect measures people's beliefs in knowledge about the attitude object and finally, the behavioral aspect measures people's inclination to act towards the attitude object. In the current study, the attitude object is urban and peri-urban vegetables. The responses to these statements were structured on a 5-point Likert scale (1 = strongly agree, 2, 3, 4, 5 = strongly disagree). The 13 (S_1-S_{13}) items are summarized in Table 10-1 where their means and standard deviations are also presented.

Table 10-1: Statements used to assess consumer attitudes

	ATTITUDE STATEMENT	Mean	SD
S1	I am usually concerned about safety and health aspects of all food stuffs I buy	1.82	1.086
S2	All agricultural commodities produced in urban and peri urban areas are safe for human consumption	2.99	1.143
S3	I don't mind consuming vegetables that are grown using untreated waste water	4.19	1.014
S4	I always enquire about the source of the vegetables that I buy	3.24	1.307
S5	I trust the government of Kenya in regulating food marketing and ensuring quality	3.58	1.196
S6	I can differentiate agricultural products grown in the urban and Peri-urban areas from those grown in rural areas	2.84	1.485
S7	I don't mind buying vegetables grown using untreated waste water so long as the price is lower	4.08	1.057
S8	Urban and Peri-urban agricultural products are priced higher compared to those produced in rural areas	2.21	1.203
S9	Agricultural products grown in the urban and Peri-urban areas have higher nutritive value than those produced in the rural areas	3.49	1.172
S10	Agricultural products grown in the rural areas taste better than those grown within the urban and Peri-urban areas	2.34	1.824
S11	Agricultural products grown in the urban and Peri-urban areas are not associated with health risks	3.29	1.242
S12	I trust that my vegetable vendor tells me the truth regarding the source of his/her supplies	3.68	1.297
S13	I don't mind buying vegetables that have been grown using treated waste water	2.77	1.480

Finally, to assess the determinants of the decision to purchase UPA vegetables after disclosure and the amount of premium price that consumers will be willing to pay, a double hurdle model was used [14].

This model was preferred because the decision-making process is sequential. First, an individual decides on whether to purchase the vegetables after the disclosure to them that they are produced using treated wastewater. This is usually called the participation decision. Next, the consumer must decide on the discount/ premium prices they are willing to pay after the disclosure (the quantity decision). In the first hurdle, a probit model is used to identify the determinants of the decision to buy or not to buy. In the second hurdle, a truncated regression model (Tobit) is used to determine the factors influencing the premium/ discount price after disclosure. The double Hurdle model is superior to the Heckman two-stage model because of its ability to handle zero responses in the second hurdle. Zero responses occur given that a consumer may not be willing to pay either a discount or premium price and therefore the difference between the prices will be 0. The probit model used in the first hurdle can be expressed as:

$$y_{i1}^{*} = X_i^{\prime}\alpha + v_i \quad \ldots\ldots(3)$$

where y_i^{*} is the latent variable representing the inherent benefits associated with making the purchase decision. We are able to observe the decision to purchase (y_i) satisfied the rule:

$$y_i = \begin{cases} 0 \; if \; y_i^{*} < 0 \\ 1 \; if \; y_i^{*} > 0 \end{cases} \quad \ldots\ldots(4)$$

The truncated regression model used in the second hurdle can be presented as:

$$PM_i = x_i^{\prime}\beta + u_i \text{ if } y_i = 1 \quad \ldots\ldots(5)$$

PM_i is a variable representing the discount/ premium price that the consumer would be willing to pay after disclosure, $x_i^{\prime}$ is a vector of explanatory variables (Table 2) while α and β are vectors of unknown parameters to be estimated, v_i and u_i are the respective error terms assumed to be independent and distributed as $v_i \sim N(0, 1)$ and $u_i \sim NN(0, \delta^2)$ respectively. The dependent variable in this model is calculated as the difference between the price consumers usually pay for a Kg of a specified vegetable (tomatoes) and the price they would be willing to pay after it has been disclosed to them that the tomatoes are produced using treated wastewater. The variables used in the model, their measure and expected signs are summarized in Table 10-2.

Results and discussions

Characteristics of the sampled consumers

Table 10-2 presents a summary of the characteristics of sampled consumers based on socio-demographic attributes. Consumers with higher incomes also had higher education levels indicating that higher education enables them to access better job opportunities. Richer consumers also had larger land under crops and more crop diversity. The possibility of growing own vegetables provides the household with an opportunity to produce a variety of vegetables hence being self-sufficient in dietary requirements. Wealthier households are more likely to be farming on their compounds and have more crops in their backyard plots. There was a u-shaped relationship between wealth and expenditure on fresh fruits and vegetables. Poorer households were paying more for a Kg of tomatoes compared to those in the second and third quartile probably because they buy in low quantities and therefore end up paying more. Those in the highest quartile also pay more for the same quantity of Tomatoes. This could be explained by the fact that majority of consumers in this category indicated that they were shopping in high-end outlets such as supermarkets and grocery stores (χ^2 =10.01; $p<0.001$) which charge relatively higher prices.

Table 10-2: Explanatory variables used in the double hurdle model

	All		**Income Quartiles**			
	Mean	**SD**	**Lowest**	**2**	**3**	**Highest**
Total Household income ('000/ Year)	464	1466	22	118	278	1441
Number of Crops Grown	7.45	3.274	7	8	7	9
Land Under Crops (Ha)	0.77	1.307	0.39	0.74	0.78	1.16
Number of Household Members	3.80	1.772	3.24	3.77	4.09	4.09
No. of Children Below	0.39	0.637	0.27	0.39	0.44	0.45
Education Level (Years)	9.58	8.181	7.66	8.37	10.19	12.07
Age of the household head (Years)	46.22	13.096	46.85	48.16	44.56	45.33

Head is engaged in off farm (Y=1)	0.55	0.498	0.17	0.67	0.71	0.65
Frequency of buying fruits	2.53	1.934	2.01	2.23	3.09	2.77
Frequency of buying vegetables	2.38	2.197	2.72	2.21	2.67	1.93
Price of Tomatoes (Ksh/ Kg)	46.69	15.508	49.52	45.73	43.4	48.11
Average Premium Price (Ksh)	3.57	10.617	3.33	2.5	3.85	4.59
Distance from the home to Nairobi CBD (Km)	27.07	12.778	25.93	29.75	25.49	27.07
Distance from home to vegetable vendor (Km)	0.78	1.685	0.65	0.59	0.98	0.88
Gender of the Household Head (M=1)	0.86	0.345	0.69	0.88	0.91	0.97

Patterns of UPA product purchase and consumption

Figure 10-2 presents the foodstuff consumed by the sample respondents weekly, either sourced from the market or own production. Vegetables ranked first, followed by condiments, oils and staple cereals such as maize, rice and wheat. The most consumed vegetables were the dark green vegetables (i.e. spinach, kales and cowpea leaves) followed by the red/ orange vegetables (i.e. carrots and tomatoes).

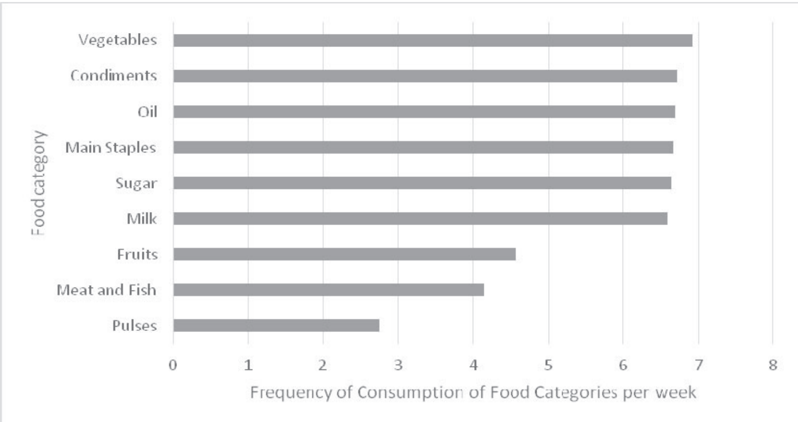


Figure 10-2: Frequency of Consumption of Food Stuffs in Days per Week

The dark green vegetables were mainly sourced from own production while the orange/ red vegetables were mainly sourced from the market.

Some consumers have the opportunity of producing some leafy vegetables in their compounds and plots close to nearby rivers. The main outlets where consumers sourced their vegetables from included the open markets (77.0%), supermarkets/ grocery stores (14.7%) and farm gates (8.3%). The open market still dominates the fruit and vegetable market in Kenya and the outlets handle a large percentage of fresh produce sold in urban centers [1], [15]. Farmgate purchases happen among a minority 8% and particularly, the consumers who live close to people who farm on own compounds. Farmgate outlets were preferred mainly due to lower prices, convenience and better-quality products. Consumers were more confident that fruits and vegetables purchased directly from farms, where they could have a feel of the production methods, were of better quality.

Roadside kiosks and the open markets were preferred mainly because of their convenience; given that they are located within the residential areas hence easily accessible. Consumers also believed that the open market outlet had a more reliable supply of agricultural produce. This outlet also ranked slightly higher on the provision of credit services. The open market system in Nairobi is a highly non-regulated market where consumers engage in spot purchases both at retail and wholesale markets. The vegetable retail vendors in roadside shades within the residential estates offer convenience services to consumers, including slicing. Given the porosity of the open market and roadside shades, these are the outlets through which the urban and peri-urban products are retailed (Figure 10-3).

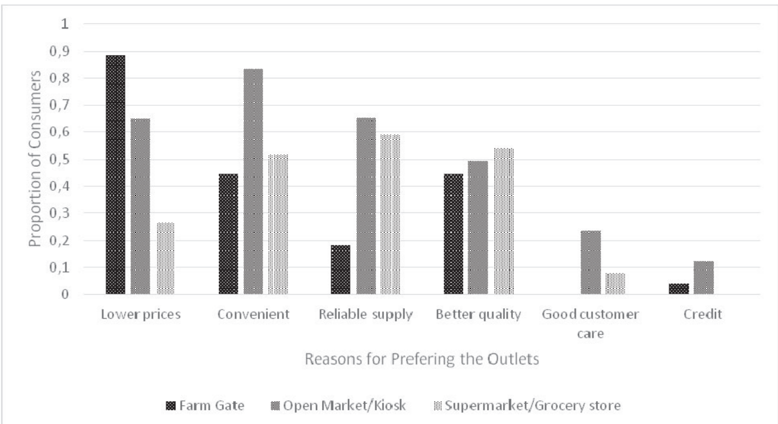


Figure 10-3: Vegetable Purchase Patterns among Urban Consumers

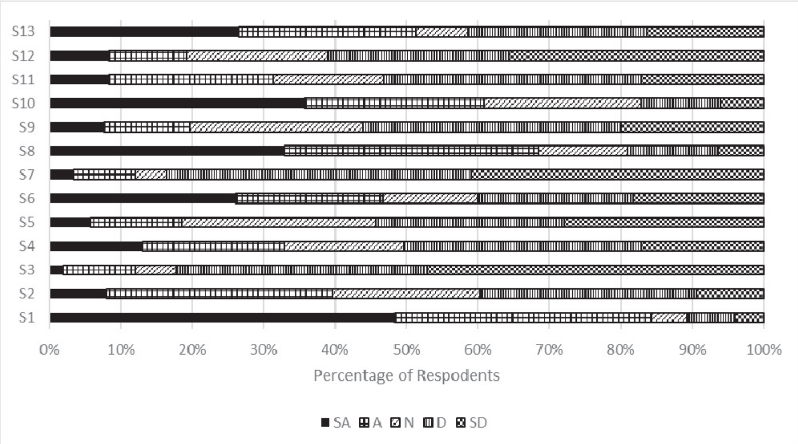
A minority of consumers indicated that they were purchasing their fruits and vegetables from grocery stores and supermarkets. These outlets are mostly located within shopping malls and are preferred mainly due to their convenience because consumers can combine the shopping for groceries with that of other household food and non-food items. Consumers also believed that produce from the supermarkets and grocery stores are of good quality. The current study also sought to determine the factors that matter to consumers when making purchase decisions. Consistent with the findings by [9] in Ghana, consumers were least concerned about health considerations when making purchase decisions but rather they considered prices, convenience, taste and freshness.

Consumer decision with new information

Information on the source of agricultural produce and the method of production can make a difference in consumers' decisions. Particularly, consumers who have a negative attitude on products produced using wastewater are more likely to keep off the products unless some information is available concerning the sources. Majority of the surveyed consumers (66%) indicated that with such information available, they would change their minds and buy vegetables they would otherwise not buy. Out of those who would be willing to change their minds after disclosure, about 34% indicated that they would pay an average premium of Ksh. 15 (*Range Ksh. 3.50-25*) for tomatoes produced using treated wastewater. The premium that consumers are willing to pay was negatively correlated with the age of the consumer. The older consumers seem to be more concerned with the type of commodities that they consume as well as their sources. Further, decisions of consumers who are employed and were in the high-income quartiles were less likely to be swayed by the availability of information. These consumers indicated that they were less likely to pay premium prices even when they were informed that the vegetables, they purchase were produced using treated wastewater.

Consumer attitudes on urban and peri-urban agricultural commodities

Consumer responses to the 13 statements used to gauge consumer attitudes are summarized in Figure 10-4. Each stacked bar shows the marginal frequencies of the responses for each item used to measure consumer attitudes. Respondents highly agreed with statements S1, S8, S10 and S13, implying three things. First, consumers are generally concerned about the health aspects of the agricultural products that they consume. Second, there is a strong preference for products from rural areas compared to those from the urban and peri-urban areas. Third, majority of the consumers have the perception that the treatment of wastewater is good and improves the acceptability of urban and peri-urban agricultural products. Consumers highly disagreed with statements S3, S7 and S12. Disagreeing with these statements implies that consumers have a negative attitude towards the use of untreated wastewater to produce agricultural commodities. Further, it was clear that consumers do not trust their vegetable vendors regarding information on the source of the vegetables they buy.



SA = Strongly agree A = Agree N = Neutral D = Disagree SD = Strongly disagree
Figure 10-4: Marginal frequencies of the responses on the 13 statements used to gauge attitude

To further assess consumer attitudes on urban and peri-urban agricultural commodities, principal component analysis was conducted with Varimax rotation, with sampling adequacy verified using the Kaiser-Meyer-Oklin measure. The KMO was 0.497 and the KMO values for each variable were >0.67 which is above the acceptable limit according to [16]. To assess whether the correlations were large enough to use PCA, we used Bartlett's test for sphericity χ^2 (7) = 6.786, $p < 0.001$. The Eigen value was used the criteria for selecting components to be included in the final analysis. All the components that had Eigen values greater than the Kaisers criterion of 1 were retained. This criterion was further validated using the screen plot which gave consistent results. The factor loadings after rotation are presented in Table 10-3. Three components were extracted to represent consumer attitudes on urban and peri-urban agricultural commodities within Nairobi. Items that loaded into the first factor indicated that Nairobi metropolitan consumers are concerned with the source of the vegetables that they buy. Preference is given to vegetables produced in the rural areas as opposed to those produced in urban and peri-urban farms. The second factor had high loadings on statements that captured consumer knowledge on attributes of vegetables. This factor revealed that consumers' attitudes were influenced by information on sources and that they would rely on their general knowledge or their vendors to validate their concerns. The last factor revealed that consumer attitudes on urban and peri-urban agricultural commodities are influenced by the knowledge on production methods. The factor loadings and Cronbach's Alpha statistics as a reliability measure are presented in Table 10-3.

Table 10-3: PCA results: extracted factors, factor loadings and Cronbach's alpha

	Corr. Coefficient	Cronbach's Alpha
FACTOR 1: Attitude on source of agricultural produce		**0.734**
I trust that my vegetable vendor tells me the truth with regard to the source of his/her supplies	0.633	
I always enquire about the source of the vegetables that I buy	0.720	
I can differentiate agricultural products grown in the urban and peri-urban areas from those grown in rural areas	0.580	
FACTOR 2: Attitude on production methods for UPA products		**0.675**
I trust the government of Kenya in regulating food marketing and ensuring quality	0.414	
I don't mind buying vegetables that have been grown using treated wastewater	0.822	
I don't mind buying vegetables grown using untreated wastewater so long as the price is lower	-0.456	
FACTOR 3: Attitude on Quality of UPA products		**0.624**

Agricultural products grown in the urban and peri urban areas have higher nutritive value than those produced in the rural areas	0.436
Agricultural products grown in the rural areas taste better than those grown within the urban and peri-urban areas	-0.587
Agricultural products grown in the urban and peri-urban areas are not associated with health risks	< 0.3
I am usually concerned about the safety and health aspects of all foodstuff I buy	< 0.3
All agricultural commodities produced in urban and peri-urban areas are safe for human consumption	< 0.3
Urban and peri-urban agricultural products are priced higher compared to those produced in rural areas	< 0.3

The first factor had high loadings from the statements which reflected on the attitudes on the sources of agricultural produce. The three extracted factors were used in the double hurdle model as explanatory variables.

Double hurdle (DH) model results

The DH results indicate that the decision to purchase vegetables after the consumer has received information that they have been produced using treated wastewater is significantly influenced by consumer attitudes and perceptions, socio-demographic characteristics and their knowledge of production. Consumers who perceived the source of the vegetables they consume (rural vs urban farms) were less likely to purchase vegetables even after being informed that they are produced using treated wastewater. Consistent with this decision, these farmers would also not pay a premium price for the vegetables.

Table 10-4: Determinants of decision to buy vegetables after disclosure treatment of waste water and the amount of premium

	Tier1 (Probit)		Tier2(Tobit)	
	Coeff.	**SE**	**Coeff.**	**SE**
Perception on Source of Vegetables	-0.030***	0.082	-0.086**	0.271
Perception of production method	-0.035***	0.087	-0.237**	0.271
Perception on Quality of UPA	0.027	0.089	-0.380	0.248
Gender of Household Head (M=1)	0.447*	0.238	-0.745*	0.950
Age of Household Head (Years)	-0.008	0.007	0.000	0.023
Distance to NBI CBD	0.003	0.006	0.025	0.024
Income (Ksh/Annum)	-0.145***	0.038	0.332***	0.167
Shopping at Farm gate (Yes=1)	-0.243	0.377		
Buying at Kiosk (Yes=1)	-0.643*	0.245		
Distance to Veg Vendor (Km)			0.089	0.267
Head in Salaried Employment (Y=1)	-0.290***	0.179	-0.201***	0.573
Number of Children below 5	-0.050**	0.133	0.335	0.428
Education Level (Years)	-0.011*	0.004	-0.001**	0.016
Freq. of buying Vegetables	0.064	0.041	0.110***	0.121
HH uses Waste water for production	0.012**	0.190		
Land Size	-0.058	0.065		
Constant	-0.712***	0.703	11.381	2.586***
Sigma	3.517***	0.187		
Wald $\chi^2(16)$	37.57***			
N	298			

*,** & *** coefficients are significance at 0.1, 0.05 and 0.01

Older consumers seem to be more skeptical and overly concerned about healthy diets and therefore were less likely to purchase vegetables after disclosure. Households with younger children also were less likely to purchase UPA vegetables even after disclosure, probably caused by the health concerns that parents with younger children could have. People who are engaged in salaried employment were less likely to purchase UPA products after disclosure. The result was similar for consumers with higher incomes. This may indicate that in the absence of information asymmetry, the market for UPA products may be limited to low income and unemployed consumers. This could explain why the UPA sector is surrounded by large instances of information asymmetry. Prior experience of using wastewater had a positive effect on the decision to purchase UPA products after disclosure. Households who have been using wastewater (treated or untreated) seem to have already authenticated the practice and therefore were more likely to purchase UPA products and pay a premium price.

Conclusion and policy implications

The current study has analyzed consumer attitudes and perceptions on vegetables produced in urban and peri-urban agricultural systems. Further, the value of information on the production methods, particularly the use of treated wastewater in UPA systems was assessed. Results indicate that the vegetable market within Nairobi is characterized by high levels of information asymmetry. One way of eliminating the information asymmetry is to disclose information to consumers about the production method, particularly the type of water used in the production of UPA vegetables. The reaction of consumers to new information and the effect on purchase behavior was found to differ depending on consumer socioeconomic attributes. Disclosure of the information to the effect that vegetables were produced using treated wastewater is likely to work negatively among older consumers, those who are employed and those who are in the high-income categories. On the other hand, jobless and low-income consumers were found to be relatively indifferent and less sensitive to information disclosure. These results have important implications for the development of the UPA agricultural sector. In the short run, if a larger segment of the urban population is poor and unemployed, the UPA products will have substantial demand. However, in the long run, as the city develops and more consumers get richer accompanied by the streamlining of the vegetable market gets into formal outlets, the market for UPA products will get thinner. In order to support the UPA agricultural sector, there must be deliberate efforts to constantly improve the UPA production methods, particularly through efficient wastewater treatment technologies. The usage of such technologies should also be accompanied by intensive consumer education on the safety of treated waste-water.

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CHAPTER ELEVEN

POTENTIAL FOR WASTEWATER RE-USE IN URBAN AND PERI-URBAN AGRICULTURE TO MITIGATE HOUSEHOLD FOOD INSECURITY IN NAIROBI, KENYA

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Abstract

Global trends indicate rapid urbanization among cities in developing countries. Consequently, poverty, food insecurity and malnutrition levels have been increasing among urban populations. Urban and peri-urban agriculture (UPA) is increasingly gaining recognition because of its critical role in shaping food security. In Kenya, wastewater re-use has been utilized in household food production due to the scarcity of water resources. Despite its potential to contribute to UPA, food safety concerns arise from its utilization. There is need for scientific evidence on the role of wastewater re-use in enhancing agricultural production. The main objective was to establish the potential of wastewater re-use for UPA in mitigating the household food insecurity among urban and peri-urban (UP) areas in Nairobi County, Kenya. Using a cross-sectional study design, a household survey was conducted in UP areas of Nairobi County; Juja, Ruiru, Ruai, Githurai, Athiriver and Waithaka metropolitan areas. A total of 300 farmers were randomly selected using lists from the Ministry of Agriculture and proportionately represented from each metropolitan area. A structured questionnaire was used to gather information on land ownership, wastewaters re-use and UPA practices. Household food security was assessed using a dietary diversity questionnaire and household food insecurity access scale (HFIAS). Fifteen samples were randomly sampled from the study sites. Microbial and chemical wastewater quality determined using standard analytical methods. Land ownership varied among the UPA farmers; owned (38.1%), rented (40.9%), owned by relatives (2%) and road reserves (9.6%). All farmers practiced crop production with 64% of the farmers practicing animal production. The main sources of irrigation water were: rivers (68.6%), household wastewater - open and closed sources (3.4%), borehole (10.6%) and rainfed (17.4%). All irrigation water samples did not meet chemical quality whereas 53.3% conformed to microbial quality for irrigation water [1]. The main household food source was own production (51%). A majority had household dietary diversity scores (HDDS) ≥4 (98.7%). HDDS for those farming on their compounds were higher (7.1±1.2) than those farming on river banks (6.5±1.7). According to HFIAS, majority of households were food secure (75.6%) whereas 7.0%, 11.4% and 6.0 % were mildly, moderately and severely food insecure respectively. UPA has the potential for contributing to food security among urban populations. Compliance with government legislation on wastewater re-use should be ensured for safe foods.

Background

Urban and peri-urban agriculture (UPA) is defined as any agricultural activity which involves production, transportation, processing and sale of crops, rearing of animals, fish farming and agro-forestry regardless of land size and the number of human resources within the cities and towns [2]. Global trends indicate a rapidly growing population in urban areas and two-thirds of the world's population is projected to live in urban areas by the year 2050 [3]. According to a report by the United Nations

Department for Economic and Social Affairs, there is a projected increase in the urban population in Africa by an estimated 90 percent [4]. Population growth is associated with increased poverty levels and increased demand for food, water and land resources [5]. In African countries, household food production for own consumption is rarely practiced among the urban dwellers. Consequently, a large proportion of household income is utilized to meet food budgets. This translates into an increased vulnerability of the urban poor to malnutrition and food insecurity [6]. Because of the growing urban population and due to the advantage of market proximity and freshness, the market for UPA food products has been expanding [7]. There is growing recognition that food production by urban dwellers contributes to improved household food security [8].

In Kenya, farming in the urban and peri-urban (UP) areas is increasingly gaining significance. Mwangi and others reported that 60-70% of low-income women in urban areas are involved in urban agriculture and livestock keeping [9]. However, land and water resources for urban agriculture are getting scarce due to population growth and climate change. Some urban farmers divert municipal water to farming further exacerbating water shortages [10]. According to an FAO report [11], the most viable source of water for UPA is recycled treated wastewater as the effluent from domestic sources, is rich in nutrients such as nitrogen, phosphorus and potassium. Wastewater re-use is also considered as an environmentally friendly method of waste disposal [12].

Wastewater re-use in Kenya is common during the dry seasons and is mainly utilized for the production of vegetables [13]. Kimani and others also reported that formal recycling of wastewater for agricultural use is rarely practiced in Kenya despite the richness in nutrients and the recurrent drought conditions [13]. The use of raw wastewater for agricultural production is associated with pathogenic microorganisms among other contaminants, therefore, posing a health hazard to the consumers [14]. Wastewater coming from domestic and industrial effluents is also reported as a major source of irrigation water in urban areas in Kenya [15]. The effluents are usually discharged to rivers untreated despite the national legislation governing wastewater re-use for irrigation purposes [16]. There is scarcity of information on wastewater re-use and the potential for enhancing household food security in UP areas in Kenya. The current study sought to investigate the UPA practices, wastewater re-use and household food security in urban and UP areas in Nairobi, Kenya.

Methodology

The study adopted a cross-sectional survey design. The target population was small-scale farmers practicing UPA farming in Nairobi city and its environs in Kenya. A total of 300 farmers drawn from Juja, Ruiru, Ruai, Githurai, Athiriver and Waithaka metropolitan areas were interviewed upon seeking informed consent and voluntary participation. A farmer list was obtained from the Ministry of Agriculture. A farmer household was randomly selected using a random numbers generator. The number of farmers from each region was determined using proportionate sampling. A semi-structured questionnaire was administered by enumerators on who were trained and successfully evaluated on interviewing skills. The persons responsible for the farming activities were interviewed on the household socio-demographic and socio-economic characteristics, UPA practices, waste-water re-use and the household annual food production for the period between July 2015 and June 2016. The respondent for the household food sources and dietary practices was the person involved in the household food preparation. Household food security was assessed using a household dietary diversity questionnaire, and a household food insecurity access scale (HFIAS) and the food consumption patterns assessed using a 7-day food frequency questionnaire. The foods consumed by the households in the 24-hour recall period helped in determining household dietary diversity. The household dietary diversity score was computed considering 12 food categories [17]; fleshy food/ meat, egg, dairy, cereal and root/ tubers, legume (legumes, nut, seeds), dark green leafy vegetables, other vitamin A-rich vegetable/ fruit, other fruit and vegetable and organ meat. Starchy staples, roots, and tubers were combined to form the cereal, roots, and tubers food group, while the flesh foods group was formed from a combination of meats and fish. Consumption of a minimum of 4 food groups or more in the previous 24 hours was considered as adequate dietary diversity. Three or fewer food groups were considered as low food diversity, four to five food groups were medium dietary diversity and 6 and more food groups were considered as high food diversity. Frequency of food consumption by a household during the 7 days before the survey was assessed by grouping the foods into eight groups; main staples, pulses, vegetables, fruits, meat and fish, milk, sugar and oil [18].

HFIAS consisting of nine occurrence questions were used to assess the respondents' perceptions of food vulnerability or stress as well as their behavioral responses to food insecurity over the previous four weeks before the interview. The questions address the situation of all household members. The HFIAS score was calculated by summing the codes for each frequency-of-occurrence question. The score was used to categorize households into food secure, mildly food insecure, moderately food insecure and severely food insecure. Pre-testing of the questionnaires was conducted among 10 households randomly selected in Kahawa West ward. The reliability coefficient of the instruments was calculated using Cronbach's coefficient alpha [19]. Quantitative data collected was cleaned, coded and analyzed using the computer software programme Statistical Package for Social Sciences (SPSS) Version 21. Descriptive statistics such as percentages, frequencies, and means were used to describe the quantitative data.

Results

Urban and peri-urban agriculture practices

Land ownership was varied among the UPA farmers; owned (38.1%), rented (40.9%) road reserves (9.6%), borrowed (8.3%), owned by relatives (2.0%) and leasehold (1.1%)(Figure 11-1). All farmers practiced crop production with 64% of farmers practicing animal production. Only 2.7% practiced the landless system of agricultural production; multi-storey gardens (2%), bottle gardening (0.3%) and hydroponics (0.3%). Greenhouse technology was observed among 0.7% of the farmers.

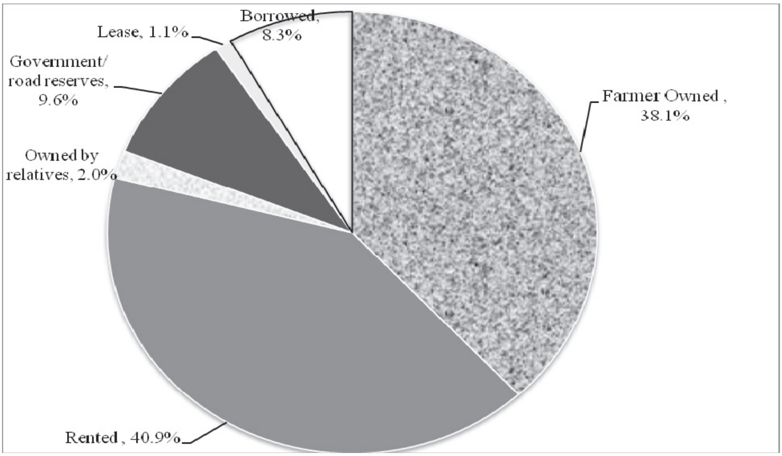

Figure 11-1: Land ownership by the UPA farmer households

Water sources and wastewater re-use for urban and peri-urban agriculture

The main source of irrigation water was rivers (68.6%). Other sources included; borehole (10.6%) and rainfed (17.4%). Open and closed domestic wastewater systems were rarely used (3.4%) (Figure 11-2). In the current study, river water was considered as wastewater. This is mainly because the main rivers flowing along the UP areas were polluted by both domestic and industrial effluents as evidenced by the chemical and microbial analysis on the irrigation water quality (Table 11-1).

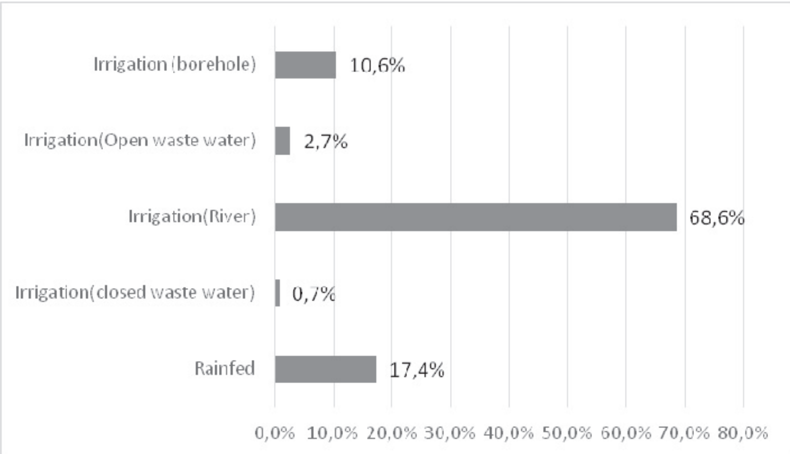

Figure 11-2: Irrigation water sources and waste water re-use for UPA

Irrigation water quality

Representative samples randomly collected from rivers in the different UP areas indicated possible contamination by chemical residues in some sites. However, heavy metals of concern in food safety were not detected. The microbial quality indicates feacal contamination in nearly half of the samples (46.7%) as evidenced by the presence of *Escherichia coli* an indicator microorganism (Table 11-1).

Table 11-1: Chemical and microbial quality of irrigation water from rivers in Nairobi area

Parameter	Range	Permissible Levels	Non-compliance n(%)
pH	7.3- 8.6	6.5 - 8.5	1 (6.7)
Chlorides (ppm)	5.24 - 128.0	0.01	15 (100)
Fluorides (ppm)	0.20 - 6.80	1	6 (40)
Aluminium(ppm)	0.07 – 1.60	5	NIL
Boron (ppm)	0.02 - 0.65	0.1	2 (13.3)
Copper (ppm)	0.01 - 0.02	0.05	NIL
Iron (ppm)	0.3 - 1.6	1	6 (40)
Zinc (ppm)	0.01 - 0.05	2	NIL
Arsenic (ppm)	0.005 - 0.007	0.1	NIL
Cadmium (ppm)	0.001 - 0.002	0.5	NIL
Chromium(ppm)	0.001 - 0.004	1.5	NIL
Cobalt (ppm)	< 0.001	0.1	NIL
Lead (ppm)	0.009 - 0.010	5.0	NIL
Selenium (ppm)	0.02 - 0.05	0.190	NIL
E. coli(CFU/100g)	1 - 6	NIL	7 (46.7)

The distribution of the hotspots (indicating areas with a high farmer household concentration) shows that some of the UPA farming activities were intensified in areas where sewer contaminated river water was employed for irrigation. Higher levels of feacal contamination were observed in Athiriver, Kawangware and Ruai hotspots (Figure 11-3).

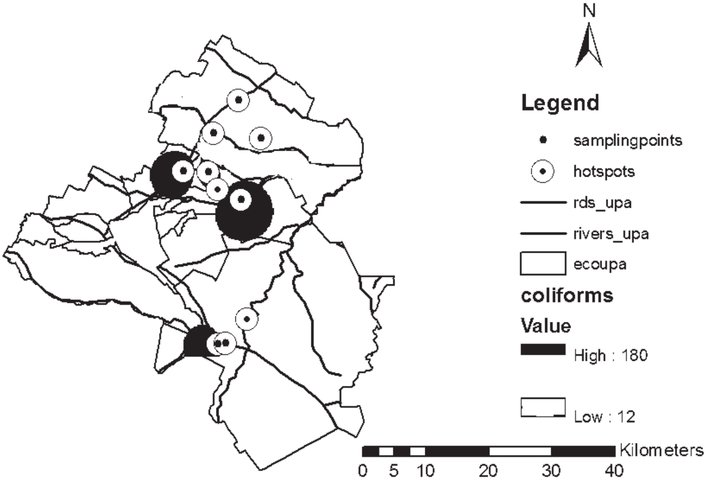

Figure 11-3: A map of the Nairobi UP areas showing the farming hot spots, water sampling points and the feacal contamination levels

3.4 Household food production

All farmer households practiced crop production with 64% of the farmers practicing animal production. Crop production was dominated by the cultivation of green leafy vegetables such as kales, spinach, cowpeas, tomatoes and indigenous vegetables. Fruits were rarely produced. The annual production shows that bananas were the main types of fruits grown with low production of pawpaws. Maize was commonly grown, with dry maize commonly preserved for home consumption and green maize produced mainly for sale. Legume production was low as observed in the annual volumes of beans harvested. Unlike maize and beans which were mainly grown for household consumption, most of the vegetables were grown for sale (Table 11-2).

Table 11-2: Household crop production, sales, consumption and postharvest losses

Crop	Mean Annual Production (Kgs)	Sales (%)	Consumption (%)	Postharvest Losses (%)
Maize, dry	170,1	23,9	76,1	1,3
Maize, green	238,0	67,7	32,4	0,3
Beans	38,2	14,0	86,0	5,5
Bananas	105,6	42,8	57,2	0,6
Cowpeas leaves	126,0	91,4	8,7	0,9
Arrow roots	14,4	69,6	30,4	0,0
Pawpaw	2,9	91,0	9,0	0,0
Tomatoes	616,2	89,8	10,2	6,9
Sukuma Wiki (Kales)	2584,1	92,5	7,5	0,5
Spinach	2251,2	85,6	14,4	0,3
Indigenous vegetables	2081,7	90,5	9,5	0,2
Lettuce	123,3	93,4	6,6	0,5
Dhania	26,3	94,8	5,2	0,2
Others	747,1	75,5	24,5	4,8

Nearly half (43.6%) of the households who practiced animal production were mainly involved in the rearing of indigenous chicken with a few households (12.5%) rearing dairy cattle and dairy goats (2.9%). Other animals included local breed goats, sheep, rabbits and pigs (Table 11-3).

Table 11-3: Household animal production

Animal type	No. of Households	%
Local breed goats	33	9,6
Dairy goats	10	2,9
Local cattle	27	7,8
Dairy cattle	43	12,5
Sheep	26	7,6
Indigenous Chicken	150	43,6
Improved Indigenous Chicken	5	1,5
Layers	6	1,7
Pigs	17	4,9
Rabbits	27	7,8

Apart from cow milk, other animal products harvested for sale were eggs (32.4%), manure (34.2%), goat milk (8.5%), hides and skin (18.2%). Fish was only produced by 0.2% of the households (Table 11-4).

Table 11-4: Animal products sold for household income generation

	No. of Households	%
Goat milk	42	8,5
Eggs (if not hatched)	160	32,4
Fish(if have fish pond)	1	0,2
Hides and skin	90	18,2
Wool	26	5,3
Manure (only if sold)	169	34,2

3.5 Household food sources, food consumption patterns and food Security

Majority of the interviewed respondents (51%) indicated that the main source of food for their households was from own production. Pulses, meat, eggs, fish and fruits were rarely consumed compared to starchy staples, vegetables and milk (Figure 11-4).

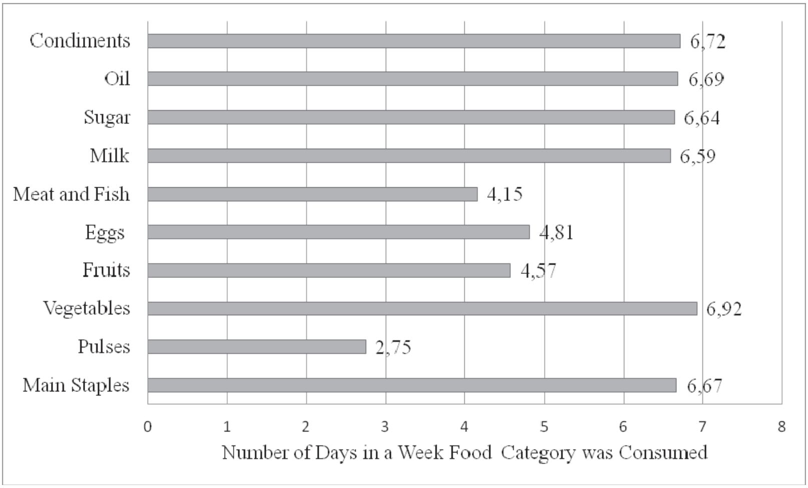

Figure 11-4: Frequency of household consumption of food groups in a week

Different indicators can be used to demonstrate the multidimensional picture of household food security. HDDS portrays the quality whereas HFIAS indicated quantity and stability aspects of the household food situation. The mean HDDS was 6.58. Majority of the households had HDDS ≥4 (98.7%). The households with the lowest (HDDS≤3), medium (HDDS 4 - 5) and highest (HDDS ≥6) food diversity were 1.3%, 20.8%, and 77.9% respectively. The HDDS for those farming on their compounds were higher (7.1±1.2) than those farming on river banks (6.5±1.7). Among the UPA areas, Athiriver had the lowest mean HDDS whereas the highest HDDS was observed in Kawangware-Waithaka areas (Figure 11-5).

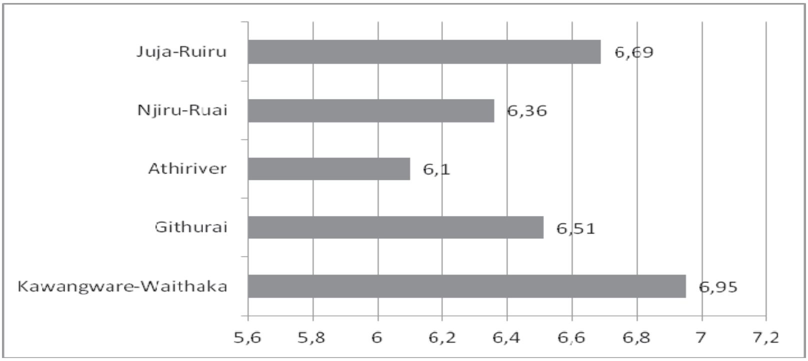

Figure 11-5: HDDS of the UP areas in Nairobi

According to HFIAS, majority of the households were food secure (75.6%) whereas 7.0%, 11.4% and 6.0 % were mildly, moderately and severely food insecure respectively (Figure 11-6).

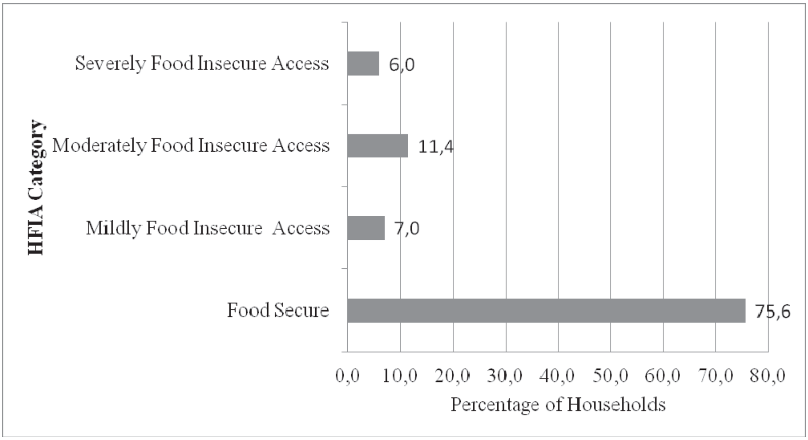

Figure 11-6: Households food security as depicted by the HFIAS categories

Discussion

Lack of adequate land and water resources are some of the main challenges faced by UPA farmers in Kenya today. The findings of the current study show that only a few of the UPA farmers owned land with the majority relying on renting, borrowing and a few utilizing road reserves. Overcrowding among urban cities results into the encroachment of government land (road reserves and riparian land) for farming purposes [20]. Despite the scarcity of land resources, farming used the no-space or low-space technologies which offered opportunities to farmers to mitigate the lack of land resources [21]. However, these technologies were rarely practiced in the UP areas of Nairobi.

Water is a scarce resource for agricultural production in UPA areas therefore a great need for wastewater recycling. The findings of the current study indicate that household wastewater reuse was not commonly practiced by UP farmers. The hot spots for agricultural activities in the UP areas in Nairobi were highly concentrated along the rivers flowing within the city. In Kenya, industrial and household effluents are usually discharged into the rivers untreated as reported by researchers conducting an assessment of industrial effluents from selected sites in Nairobi [16].

This is evidenced by the poor chemical and microbial quality observed in the quality of river irrigation water. A study by Karanja and others that conducted analyses of water, soil and plant samples grown in the UP areas in Nairobi reported similar findings [22]. The report, however, showed high levels of heavy metals that were not detected in the current study. This could be attributed to the renewed efforts by the National Environment Management Authority (NEMA) in the close monitoring of the industrial effluents [23]. It is evident from the findings that little efforts are directed to the treatment and monitoring of domestic sewer discharges.

Dietary diversity is an indicator of household food insecurity indicating the consumption of varied foods drawn from different food groups. Dietary diversity has been reported to correlate with the adequacy of nutrient intake and consequently improved nutrition status [24]. In the current study, a majority of the households were food secure according to both HDDS and HFIAS categories. Majority of the households relied on own food production which implies that UPA played a great role in contributing to food availability but also the quality of the diet consumed. However, the food consumption patterns observed indicates that foods such as meat, fish, eggs, legumes and fruits were rarely consumed. A similar pattern was observed in the agricultural production of these foods. The findings of the current study corroborate with the findings of Korir and others who reported a significant contribution of urban farming to the household food security [25]. Despite the high dietary diversity, poor consumption the foods rich in proteins and micronutrients may be an indication of inadequate nutrient intakes among the study population. The sale of UPA produce which was observed among the majority of the farmer households also contributes to increased household income which has the potential for contributing to household food security.

Conclusion and recommendations

Urbanization rates among the major cities in developing countries are accompanied by challenges in land and water resources and consequently food security. UPA has the potential to contribute to household food security through own food production and income generation. Wastewater reuse offers an opportunity for UPA farmers to enhance their agricultural productivity. Despite the potential for wastewater reuse for UPA production, food safety and health concerns due to microbial and chemical contaminants pose the greatest challenge. Regulatory efforts are therefore needed with frequent monitoring on the treatment of effluents emanating from industries and sewer lines. Implementation and adherence to policies and regulatory requirements of wastewater reuse for agricultural purposes by the key players should be adhered to.

Conflict of interest

The authors declare no conflicts of interest.

Ethical considerations

Informed consent was sought from all study participants and confidentiality was ensured.

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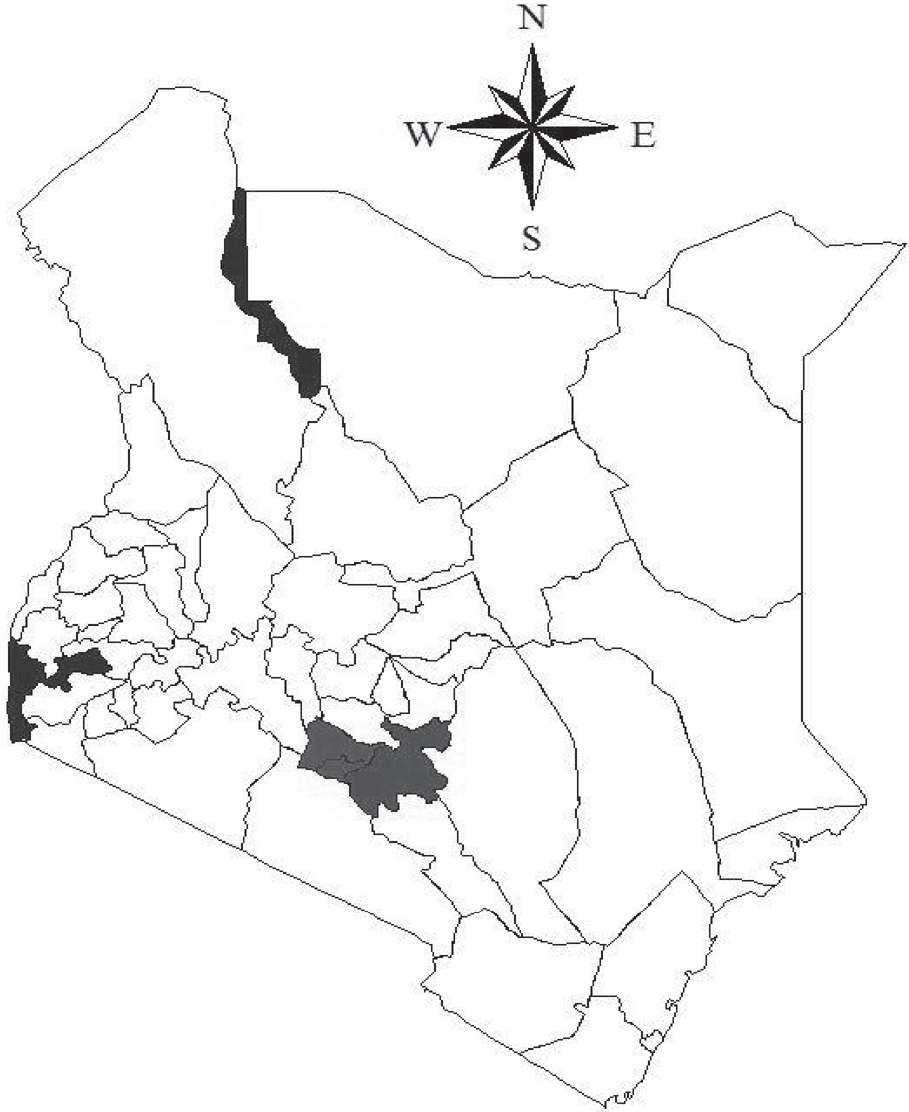
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