Food Safety, from Farm to Fork

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Emerging and Re-emerging Issues

Edited by

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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) Natural in holes cushioned with green grass (inbuilt ethylene)	More than 5 5	Black colour Green colour
Singal, Kumud and Thakral 2012	India	Banana (a bunch of 6 bananas)	CaC_2 1g 2g Apple (1 fruit) Natural (control)	 5 4 3 10	 Soft and good peel colour Poor in flavour Soft and good peel colour
Mebratie et al. 2015		Banana	Smoke Ethephon Low density polyethylene plastic Teff straw and banana leaf (control)	8 10 13 14	 Good yellow peel colour Dull yellow colour
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^oc)		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 18ºC, 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.