Full Length Research Paper

Microbiological assessment of street vended sausages sold in Harare, Zimbabwe

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ABSTRACT

The informal nature of the street food vending activities currently being carried out in some Harare areas has resulted in unhygienic and improper food handling and sanitary practices by the vendors which can potentially expose the consumers to foodborne illnesses. The study was conducted to investigate the microbiological characteristics of cooked street vended sausages sold in some parts of Harare with regards to Total Aerobic Plate Count (TAC), Total Coliforms (TC), Escherichia coli (E coli), Staphylococcus aureus spp (S aureus) and Salmonella spp. Thirty-six (36) samples of cooked vended sausages were collected from four vendors operating within Budiriro Suburbs, Copacabana Bus Terminus, Msasa Industrial Area and Belvedere (HIT) between February and May 2015. In carrying out the microbiological assessment, the isolation of the microorganisms was done according to AOAC Official Methods of Analysis (1995), Bacteriological Analytical Manual (1992) and Compendium Methods for Microbiological Examination of Food (1992). The Total Aerobic Count from all the collected samples ranged from 17×10^3 cfu/g to 139×10^3 cfu/g while the Total Coliform count ranged from 13×10^2 cfu/g to 77×10^2 cfu/g and both the TAC and TC counts were within the acceptable limits of <10^5 cfu/g and <100cfu/g respectively. The E coli counts ranged from 0 to 58×10^1 cfu/g for the samples collected. Salmonella spp and Staphylococcus aureus spp which are microbial species of public health concern were present in some of the sausage samples. The Salmonella spp counts of all the collected samples ranged from 0-7cfu/g and for Staphylococcus aureus spp, the counts ranged from 11-90cfu/g. Significant (p<0.05) variations in the microbial populations were found between vendors situated in the different locations. The results of the study indicated that the consumption of cooked street vended sausages can present a potential risk or hazard for public health; hence necessary precautionary measures need to be taken into account to improve the sanitary practices of street food vendors.

Keywords: Street vended foods, Escherichia coli, Staphylococcus aureus spp and Salmonella spp., Codex Alimentarius

INTRODUCTION

The study sought to carry out a microbiological assessment on the street vended sausages being sold in some Harare areas with regards to total bacterial count, total coliforms, Escherichia coli, Staphylococcus aureus spp and Salmonella spp. Street vended foods have been reported to be some of the common causes of food borne illnesses as most of the vendors do not fully adhere to the standards of...
hygiene or proper sanitary practices (World Health Organisation, 2006). This exposes the street vended foods to high probability of bacterial contamination at the various stages of the production chain, distribution, food preparation and handling of the food sold. According to Luccar and Forres (2006), street food vendors are involved in the preparation and sale of any foods which might be ready to eat or main dishes that require cooking or some other treatment like slicing and cutting and they mostly operate in open street pavements or unauthorised open places which lack basic kitchen hygiene practices, equipment and refrigeration facilities, hence this exposes the food to possible contamination. In Zimbabwe, most street food vendors operate without regulation or monitoring by the responsible authorities on the food they prepare, how they prepare and where they prepare their food. In developing countries like Zimbabwe, the street food vendors are not trained or educated on proper and safe food handling practices which include safe food storage and preparation, personal hygiene and the effects of cross contamination of food with the microorganisms in the environment. In Harare, amongst the food sold by the street food vendors nowadays, sausages have become one of the most common food used as a source of protein however, the safety of the meat product as a street vended food can be a public health concern.

Due to the current decline of economic circumstances prevailing in Zimbabwe and shortage of employment opportunities, people have been pushed by the difficulties to engage in unauthorised street food vending practices. This has resulted in the rampant selling of sausages both raw and cooked by vendors on the street and in other public places in and around Harare. However, the street food vendors operate in places that have insufficient facilities which in turn hinder proper hygienic and sanitary practices to be followed by the vendors during food preparation. These operating conditions are unsafe and expose the street vended sausages to microbiological contamination and poses health risks to the consumers.

In addition, there has been an expansion of the informal sector in food manufacturing industries as a survival strategy for most people in Zimbabwe. According to Ministry of Health and Child Care (2010), the production of food in unregistered premises in and around Harare Central Business District is on the increase and this has resulted in the consumption of unsafe foods including meat products such as sausages which can be microbiologically contaminated. This in turn threatens the health of the customers.

According to the World Health Organisation (2000), an estimated number of 48 million people die from foodborne related illnesses and diseases annually and globally. In Zimbabwe, The Ministry of Public Health and Child Care (2014), states that estimated number of 30 000 of people suffer from foodborne diseases annually. Some of street food vendors have resorted to selling sausages. According to the Public Health Act of Zimbabwe, the sale of meat and meat products by unregistered people or companies is prohibited as it exposes the health of the public to foodborne illnesses and diseases. Therefore the study was carried out to conduct a microbiological assessment of cooked street vended sausages. The sausages were sampled from four different locations in Harare and these where Budiriro Suburbs, Msasa Industrial Site, Belvedere (HIT) and Copacabana Bus Terminus. Budiriro Suburbs was selected for the reason that it is a high density suburb that is densely populated and characterised by street food vendors. Msasa Industrial Site was selected since street food vendors were spotted occupying open places in the industrial area and selling their foods to workers during their breaks. Copacabana Bus Terminus which is situated in the central part of Harare town was selected due to the busy patronage of commuter omnibuses transporting people into and out of town and because of the density of the people at the bus terminus at any time of the day, which provides a favourable market for street food vendors. Belvedere (HIT) was selected since it is characterised by the presence of students who mostly rely on cheap sources of food. The microbiological assessment of street vended sausages is an important factor to appreciate the safety risk and problems related to the street foods so that concerned bodies may take appropriate action to improve safety and sanitation with respect to the informal street food vending sector.

Incidences in developing countries

According to the World Health Organisation (2013), in the year 2008, it was estimated that Africa and other developing parts of the world which include South Asia had the highest incidences of food borne illnesses and diseases and Zimbabwe was amongst some of the countries who were affected.

Epidemiologic association between street vended foods and frequent diarrhoea have indicated that foods such as poultry, pork, fish and rice sold as street foods have been connected with outbreaks of food poisoning in Egypt and Ethiopia (Wilson, 1995). A study carried out in Ethiopia on minced meat stated that the meat product had high levels of indicator organisms as well as food pathogens. According to World Health Organisation (2014), 544 cases of severe diarrhoea were reported in the province of Nampula in Mozambique. The diarrhoea resulted in extreme dehydration and shock from excessive loss of bodily fluids and caused death in as little as 3 hours.

An outbreak linked to street vended foods was reported from Zimbabwe’s National University of Science and Technology (Ministry of Public Health and Child Care, 2010). Street vendors are a popular source of lunch and
Implications of foodborne incidences

The presence of foodborne pathogens in a country’s food chain affects the health of the local population and can potentially spread to visitors to the country as well. According to Wilson (1995), biological contaminants which are mostly bacteria, viruses and parasites contribute to the major causes of food-borne diseases or illnesses. In developing countries such as Zimbabwe, the contaminants are accountable for a wide range of diseases, including cholera, E.coli gastroenteritis and salmonellosis. According to World Health Organisation (2002), about 2.1 million children in developing countries die due to diarrhoea-related illnesses annually. Foodborne incidences can therefore affect the health of the consumers. In cases of foodborne incidences, the vendor is prone to loss of sales when consumers avoid their food. This in turn affects the family relying on the profits from the business.

Foodborne incidences are associated with costs of health care and death. This results in economic implications for individuals, their families and health care systems of a country and also international trade rejections. For a country, the cost of health care include costs estimated for the number of days of treatment per individual suffering from foodborne disease, average cost per treatment or service and the number of patients treated per month or annually. According to Roberts (1990), the medical and values of lives lost due to just five foodborne infections in England and Wales was £300-700 million per year. Canada loses $1.3 billion due to foodborne pathogens per year. The US Food and Drug Administration stipulated that the total economical aspect of foodborne diseases is a loss of $5-17 billion every year.

literature review

Definition of sausages

According to American Meat Institute Foundation (2009), sausages are defined as commuted processed meat products made from red meat, white meat or a combination of these together with water, binders, seasoning and preservatives. Sausage manufacture is a process that allows different types of meat to undergo series of controlled structural and chemical changes depending on the formulation of the manufacturer and their desired distinct characteristics like the shelf life and organoleptic value. According to Oluwafemi and Simisaye (2006), sausage production can also be described as a process of adding value to meat offcuts and increase the utilisation of meat and this contributes to their characteristic competitive prices since they utilize meat leftovers which are a cheap source of raw material. They can be available in fresh form and sometimes needs to be cooked before consumption or in dry or cured form which are already cooked. A sausage is formed in a casing traditionally made from animal intestines but sometimes synthetic. According to Magnus (1981), sausages are a category of processed meat which may be combined with other foods and are encased or formed into discrete units. The sausages can be used as a meal or used in dishes as a meal component.

The most common types of sausages in Zimbabwe are fresh sausages, cooked sausages and fermented sausages. According to Martire, Vera and Murcia (2000), fresh sausages are made from fresh meat which is uncooked or uncured. They are coarsely comminuted products sold as fresh or frozen and have various degrees of chopping and meat. Fresh sausages must be kept under refrigeration prior to eating and heated just before serving. Cooked sausages are further cooked, sliced or diced primarily to add safety and convenience for the fast food and ready to eat meal sectors. They are usually cooked using the oven, grill, fat or oil to deep fry the sausages after filling. Fermented sausages are characterised by their relatively longer shelf life, which is brought about by production of lactic acid in the fermentation process. The fermentation process utilizes curing ingredients, spices and relatively large numbers of cultured microorganisms (American Meat Institute Foundation (AMIF) (1997).

Street food vending

Sausages have become one of the most commonly sold street foods by street food vendors. According to Luccar and Forres (2006), street food is a ready to eat food or drink that is sold on the street or unauthorised public places for immediate consumption. A street food vendor can be defined as any individual who offers or sells foodstuffs to the public without having a permanent built-up structure from which to sell. The vendors can be mobile or stationery in the fact that they occupy public places like street corners, streets and bus terminus. Manke et al. (2005), states that street food vending is an activity whereby people sell food informally at unrecognised sites. The vendors take food to the consumers and therefore operate from such places like school entrance and exit gates, industrial sites, street corners, market places where customers are readily available. Zimbabwe and other developing countries in
Africa are experiencing an upsurge of population growth and urbanisation from both natural increase and high rates of migration into cities and urban areas. This in turn leads to the prevalence of street food vending practices due to the prevailing rising unemployment rates, rising standards of living, economic hardships in the cities and towns among other reasons. According to Canet and N’diaye (1996), high unemployment rates are forcing people into street food vending practices. Hence street food vending is playing a role in socio-economic growth of developing countries in creating employment and providing a source of income for families in the cities. Street food vending has also been promoted by the increasing demands of fast, convenient and inexpensive sources of food of the consumers especially the low income consumers in the city and industrial sites.

Sanitary problems associated with street food vendors

There have been concerns about the nature and operational conditions of the street food vending activity in relation to hygiene and food safety. According to FDA (2011), the safety of street food has become one of the major concerns of public health around the world at large due to the increasing pace of globalisation and tourism. According to Swangjit (1998), studies on some street food vendors have showed that vendors have limited information and education on issues concerning hygienic practices. There are many factors or problems associated with street food vendors that compromise the microbiological safety of the street food. The state of the environmental surroundings of the place of operation of the street food vendors is a matter of concern. In Harare, based on observation, most street food vendors prepare and sell their foods near garbage waste sites. The majority of the street food vendors do not have proper waste disposal mediums or sites and they dispose their dirty waste near their place of operations where it is convenient to them. This results in unclean environments which compromises the safety of the food as dirty invites flies and animals like dogs and harbours microbes which might end up migrating to the food. In Zimbabwe, studies have revealed that street food vending activity has risen and this is attributed to limited economic opportunities for people. According to Luccar and Forres (2006), street food vendors operate in sites that lack infrastructure and services such as shelter, toilets, water and garbage collection and this exposes them to poor working conditions. In a study conducted in Nairobi, Kenya, it showed that street food vendors were not aware of hygienic and sanitary practice and the ready to eat meals they served which included sausages were contaminated and the consumers were at a high risk of suffering from food-borne diseases.

According to Mensah et al. (2002), a study was conducted in Accra Ghana whereby a total of 176 street food vendors were evaluated for their role in the transmission of diarrhoeal pathogens. Different pathogens which included Salmonella spp were isolated from the vendors. E coli isolates were also identified from the street food vendors and they were similar to isolates from a study carried on the children from the same locality suffering from diarrhoea. These findings confirmed that personal hygiene of the street food vendors contributes to the safety of the street food. Bromly (2000), states that most food vendors’ handle food without aprons, with uncovered hair and their nails are not taken care of and they handle a lot of things whilst at the same time handling the food and they use bare hands and all these factors can be a source of contamination to the food. They do not wash their hands regularly especially when there are long queues of customers waiting to be served. According to Mankeet al., (2005), the majority of street food vendors use utensils and equipment made from plastic and metal for cooking and serving the food which is not easy to clean and maintain and most vendors share tools and use the same tools for cutting all ingredients without washing them in-between. World Health Organisation (1989), the vendors, due to the nature of their places of operations they do not have well defined working surfaces which are easy to clean, sanitise and to avoid cross contamination between the food and the surfaces and to avoid harbourage of microbes on the surfaces. According to World Health Organisation (2002), street food vendors can be qualified as sources of pathogenic microorganisms hence the need for intensive food hygiene education of all food handlers and enforcement of food hygiene laws to ensure that this route of transmission of pathogens is disrupted.

The vendors do not have potable water facilities at their place of operation which is a critical requirement at any food preparation or handling site. This leaves the vendors with an option of bringing water from their homes in containers, which is not enough to cater for all the water consuming activities like cleaning and food preparation and end up using the same water for washing ingredients and for dishwashing thereby increasing the risk of food contamination. Street food vendors do not have proper storage facilities for the raw materials, prepared food and food leftovers. The food is normally placed in plastic containers and some foods are left in the open. Magnus (1981), states that some foods like sausages require refrigeration facilities for storage in order to minimise the growth and multiplication of microbes. The food is stored at ambient temperatures which might promote contamination by pathogenic organisms. Street food handlers do not have adequate knowledge and training on hygienic food handling. They are not aware of the necessary procedures of maintaining the safety and
suitability of food. According to World Health Organisation (2006), every vendor of food should undergo a basic training in food hygiene before operation.

**Recommended codes of practice for street food vendors**

According to the Codex Alimentarius Commission (1999), the sanitary requirements for street food vendors and their location requires that the vending sites be designed and constructed in such a way that they are sturdy and easy to clean. The food preparation surfaces should be 60cm above the ground. The food and drinks at the vendors’ place of operation must be well protected from contamination with the use of clean coverings. The ingredients and food products purchased by the street food vendors for the purpose of selling must be from known and reliable sources and they must be fresh and wholesome to maintain quality and safety of food. Other ingredients such as seasonings should be of a quality approved by the Food and Drug Administration as they might act as sources of microbial contamination. Drinking water and ice for human consumption should be clean and safe and be kept in a clean container. Utensils such as knives, spoons, dishes must be clean, in good condition and should be designed for sanitation. The utensils should be washed in three steps in suitable sinks maintained at least 60cm above the ground. Containers used should be made of glass, stainless steel or white porcelain and covers must be used for protection from contamination. Refuse containers should be available, of suitable size and designed with a cover. Lastly, the food handlers should be trained specifically on the subject’s personal hygiene and food preparation. The vendors must follow recommended and appropriate hygienic food handling practices and the must always operate with their aprons on and hair covered. Ready-to-eat foods intended for continuous serving must be protected from environmental contamination and kept at holding temperatures of 60°C and above for food served hot, 7°C or below for food served cold and -18°C or below for frozen foods. Foods should not be stored inside temperature danger zone area of 5°C- 60°C.

**Microbiological species**

**Salmonella**

Salmonella is a genus of rod shaped, Gram negative bacteria that is widespread in the intestines of birds, reptiles and mammals. It is one of the most common causes of food poisoning or foodborne illnesses and Salmonella causes a disease called Salmonellosis after eating food contaminated with the bacteria (World Health Organisation, 2006). The bacteria can spread to humans via a variety of different foods of animal origin and food can be contaminated during food processing or food handling, by unwashed hands of an infected food handler especially one who does not frequently wash hands. The contamination may be found in faeces of some pets especially those with diarrhoea. Rodents can carry Salmonella spp as well as places with poor sanitation where the bacteria can survive. According to American Public Health Association (1976), meat and meat products are most often infected with Salmonella.

According to Doyle and Evans (1999), the bacterium causes an illness known as Salmonellosis which typically includes fever, diarrhoea and abdominal pain. In people with poor underlying health or weakened immune systems, the bacterium can invade the blood streams and cause life-threatening infections. The illness can be prevented by washing hands and surfaces often. The hands, cutting boards, dishes must be washed with hot soapy water before handling food to get rid microorganisms on the surfaces as they might end up in the food and causing illnesses to the consumers. According to Tauxe (1998), in order to control and prevent contamination of food by Salmonella, raw meat must be separated from other foods during storage. The food must be cooked to proper temperatures and foods must be refrigerated promptly (WHO, 2006). According to International Commission on Microbiological Specifications for Foods (1980), ready-to-eat foods should be Salmonella free and the presence of this microorganism in food calls for the investigation of the health status of the food handlers who may have been suffering from Salmonellosis or asymptomatic carriers of the microorganism. According to Prescott and Klein (2008), processed ready to eat foods contaminated with Salmonella spp even in small numbers results in such foods being of unacceptable quality or potentially hazardous.

**Staphylococcus aureus**

According to Gay (1982), Staphylococcus is a gram-positive cocci bacterium. The bacterium is found on the skin, hair, noses and throats of people and animals. During food poisoning, Staphylococcus infections may cause diseases due to the production of toxins by bacteria. According to Bennette and Lancette (2001), Staphylococcus spp has pathogenic strains which can cause food poisoning due to heat stable Staphylococcal enterotoxin that is resistant to gastrointestinal enzymes. Staphylococcus is most commonly spread to others by...
contaminated hands. The bacteria can cause food poisoning when a food handler contaminates food and then the food is not properly refrigerated. Other sources of food contamination include the equipment and surfaces on which the food is prepared. These bacteria multiply quickly at room temperature to produce a toxin that causes illnesses (Gay, 1982).

Prescott and Klein (2008), states that the bacteria is killed and prevented by cooking or pasteurisation. The food handler must wash hands and under fingers vigorously with soap and water before handling and preparing food to prevent contamination. A food handler must not prepare or serve food if he or she has an eye or nose infection as well as wounds or skin infections on hands and wrists. To prevent prevalence of food contamination by Staphylococcus spp, food serving areas must be kept clean and sanitised. If food is prepared more than 2hrs before serving, keep hot foods hot and cold foods cold. The cooked food must be stored in a wide, shallow container and refrigerated as soon as possible (International Commission on Microbiological Specifications for Foods, 1980).

### Coliforms and E.coli

According to World Health Organisation (2006), coliforms are commonly used bacterial indication of sanitary quality of foods and water that is indicating the presence of other disease causing bacteria. They are rod-shaped, Gram negative, non-spore forming and motile bacteria which can ferment lactose with the production of acids and gas when incubated. According to Doyle (1991), total coliforms can be found in the environment and are present in large numbers in the faeces of warm blooded animals. Faecal coliform bacteria are a kind of coliforms associated with human or animal wastes and Escherichia coli (E. coli) are part of the group of faecal coliforms. According to Adesiyun (1993), E. coli is a coliform species found in the intestinal tract of warm-blooded animals its presence can be indicative of fresh pollution from human or animal waste though normally benign, some E. coli strains may be deadly and causes serious illness especially E.coli 0157:H7. E.coli can be found in meat products as meat can be contaminated during slaughter. E. coli 0157:H7 infection can be transmitted to humans by eating undercooked foods and contaminated food products and water. The infection is also spread from person to person and it indicates compromised hygiene (Doyle, 1991).

To prevent cross contamination between the food handler and the food, the food handler must wash hands with soap and hot water before preparing or eating food. To prevent cross-contamination in the kitchen and food preparation areas and raw meat and raw foods should be kept separate from ready-to-eat foods. Cooked food should not be placed on unwashed plate that held raw foods, and wash working surfaces, cutting boards and utensils after they touch raw meat and also people ill with diarrhoea should avoid preparing food for others (American Public Health Association, 1976).

### Total bacteria

Mosupye and Von Holy (1999), states that the total bacterial count represents the total bacterial load in a sample and the possible presence of pathogenic microorganisms. The amount of total aerobic bacteria is used to detect all viable microorganisms that could grow aerobically on plate count agar at appropriate incubation conditions hence as suggested by Doyle (1991), a low total bacterial count does not always signify that a product is safe for consumption as some microorganism could be suppressed by the isolation conditions. The total bacterial counts could reflect the general hygiene condition of a sample.

### METHODOLOGY

The experiments were carried out in the Food Processing Laboratory at Harare Institute of Technology to investigate the presence and levels of total bacterial count, Total Coliforms, E.coli, Salmonella spp and S. aureus in samples of street vended sausages collected from Budiriro Suburbs, Copacabana Bus Terminus, Msasa Industrial Site and Belvedere (HIT) areas in Harare. The samples were tested using conventional methods approved by the AOAC International. The results obtained from the experiments were analysed using SPSS version 16.

### Study area and sample collection

The study took place in four different locations in Harare. Sampling of the cooked street vended sausages and experiments for the microbial analysis were carried out from February to May 2015.

Sausage samples were randomly purchased from street food vendors. The thirty-six samples were aseptically transferred into sterile stomacher bags. The stomacher bags were tightly closed or zipped, labelled and immediately placed in a cooler box sterilised using 70% alcohol with frozen gel packs. The samples were transported to the laboratory and all samples were analysed within 5 hours of collection.

### Experimental design

A total of 36 samples of sausages were randomly purchased from four different locations in Harare. Nine
samples were collected at each location. The samples were analysed according to the Official Methods of Analysis of AOAC International, Compendium of Methods for the Microbiological Examination of Food and Bacteriological Analytical Manual.

Microbiological analysis/ Laboratory procedure

The microbiological analysis was carried out according to the following procedures:

Total viable/ Aerobic plate count

Sample preparation

Ten grams of each sausage sample was weighed into a stomacher bag and homogenised. This was followed by the addition of 90ml of 0.1% of Buffered Peptone Water (BPW, Merck, Germany) into the stomacher bag with the homogenised sample. The sample and diluent were mixed together. Serial decimal dilutions were made by pipetting 1ml of the food homogenate sample into a tube containing 9ml of a diluent (Ringers diluent, Oxoid, England). Another 1ml was transferred from the first tube to the second dilution tube containing 9ml of diluent. This was repeated until a dilution of $1 \times 10^{-3}$ was obtained. Petri plates to be used were labelled with the sample number and name that is from where the sample was collected, the dilution factor and date. 1ml of the sample suspension in diluent was pipetted into petri dishes in triplicate.

Pour plating

Molten Plate Count Agar (Merck, Germany) cooled to 42-45°C was poured into each petri dish. The media and the sample suspension were mixed by swirling clockwise and anticlockwise. The plates were left undisturbed to permit the gel to solidify. The plates were then overlaid with 3 to 5ml of Violet Red Bile Agar (Scharlab, Spain) and left undisturbed to allow solidifying. The petri dishes were placed in an incubator (IncoTherm, Model 295, South Africa) and incubated inverted at 35°C for 18 to 24 hours.

Counting colonies

Colonies that were purple red in colour, around 5mm in diameter or larger and surrounded by a zone of precipitated bile acids were counted. The total number of colonies per plate was multiplied with the reciprocal of the dilution used and reported as coliforms per gram or ml.

E coli

The presumptive E. coli were enumerated using the most probable number method.

Coliforms

Sample preparation

Refer to “Total Viable/ Aerobic Plate Count” section.

Pour plating

Violet Red Bile Agar (Scharlab, Spain) cooled to 48°C was poured into each petri dish. The media and the sample suspension were mixed by swirling clockwise and anticlockwise. The plates were left undisturbed to permit the gel to solidify. The plates were then overlaid with 3 to 5ml of Violet Red Bile Agar (Scharlab, Spain) and left undisturbed to allow solidifying. The petri dishes were placed in an incubator (IncoTherm, Model 295, South Africa) and incubated inverted at 35°C for 18 to 24 hours.

Counting colonies

Colonies that were purple red in colour, around 5mm in diameter or larger and surrounded by a zone of precipitated bile acids were counted. The total number of colonies per plate was multiplied with the reciprocal of the dilution used and reported as coliforms per gram or ml.

E coli

The presumptive E. coli were enumerated using the most probable number method.

Sample preparation

Refer to “Total Viable/ Aerobic Plate Count” section.

Inoculation

The samples (1ml) from each dilution series were transferred in triplicates into 16mm Durham tubes containing 9ml of Lauryl Tryptose Broth (HiMedia Laboratories, India) and gently rotated to suspend any adhering matter into the liquid. The tubes were then incubated at 35°C for 24-48 hours, (Incubator – IncoTherm, Model 295, South Africa). After incubation the tubes were observed for turbidity and gas production which was indicative of the positive result. All tubes with positive results were sub-cultured in 16mm Durham tubes of EC broth (HiMedia Laboratories, India) by transferring 1ml inoculants into 9ml broth. The tubes
were further incubated at 45°C for 48 hours and observed for turbidity and gas production.

The Most Probable Number was calculated based on results of EC tubes. 0.1 ml samples from EC broth tubes with positive results were surface spread on tellurite-cefexime sorbitol MacConkey agar (TC-SMAC) (HiMedia Laboratories, India) and further incubated at 37°C for 24 hours. The plates were examined for neutral/grey colonies with smoky centres. Presumptive E coli colonies were streaked onto Tryptic soy agar (HiMedia Laboratories, India) with 0.6% yeast extract and incubated at 37°C for 24 hours. Pure colonies were sub cultured in peptone water, incubated at 37°C for 24 hours and tested for indole production by adding 5 drops of xylene and Kovac’s reagent (HiMedia Laboratories, India). A red colour was indicative of E. coli.

**Staphylococcus aureus**

**Sample preparation**

Refer to “Total Viable/ Aerobic Plate Count” section.

**Pour plating**

Salt Mannitol Agar (Mast Group Ltd, Merseyside, UK) was poured into each petri dish. The plates were left undisturbed to permit gel to solidify and dried in an incubator with covers partially removed. The plates were then inoculated with 0.1 ml of the sample suspension and the inoculum was spread on the surface of the medium with a sterile loop. The inoculated plates were incubated at 37°C for 24 to 48 hours.

**Counting colonies**

Yellow colonies with yellow zones in the media were counted.

**Salmonella**

Sample preparation- Refer to “Total Viable/ Aerobic Plate Count” section. Pour plating- Salmonella Shigella Agar (HiMedia Laboratories) cooled to 50°C was poured into each petri dish. The plates were left undisturbed to permit agar to solidify. The sample suspension was streaked on the selective agar. The plates were incubated at 35±2°C for 18-24 hours under aerobic conditions.

**Counting colonies**

Colourless colonies with black centres were counted. Selective media plating XLD - Xylose lysine Deoxycholate agar (HiMedia Laboratories, India) was used whereby; suspected colonies of Salmonella were transferred and streaked onto the surface of the agar. The plates were incubated at 37±1°C for 24±3 hours in an inverted position and after incubation the plates were checked for growth of typical salmonella colonies. The typical salmonella colonies grow on XLD agar with a black centre a lightly transparent zone of reddish colour due to change of the indicator.

MacConkey agar - MacConkey agar (Mast Grp Ltd, UK) was used, whereby; the agar surface was dried before inoculation. The culture of suspected salmonella colonies was inoculated and streaked onto the media with a sterile loop. The streaked plates were incubated aerobically at 37°C for 18 hours. Colourless colonies grow on MacConkey agar.

**RESULTS**

The results are based on the isolation and identification of Total Aerobic Plate Counts, Total Coliforms, E coli, Salmonella spp and S aureus spp in cooked vended sausages sold in Belvedere (HIT), Budiriro Suburbs, Msasa Industrial Area and at Copacabana Bus Terminus in Harare.

The distribution of isolates in the sausage samples collected from the different locations is shown in Table 1 below. The results revealed that 2 samples, one collected from Budiriro and Copacabana were above the Total Aerobic Plate Count acceptable limit of <105cfu/g. All the Total Coliforms, E coli and S aureus spp isolated from the sausage samples collected from the different locations were within the satisfactory and acceptable limit of <100cfu/g. Salmonella spp was not detected in sausage samples collected from Belvedere. The results indicated that 6 out of 9 samples collected from Budiriro were contaminated with Salmonella spp as well as 4 out of 9 samples collected from Msasa and Copacabana Bus Terminus.

**Mean of total aerobic plate count (×103) in the street vended sausages**

The results below shows the trend of the mean of the Total Aerobic Count of the sausage sampled in different locations. Sausage samples collected from Budiriro
Table 1. Microbial counts from sampled sausages

<table>
<thead>
<tr>
<th>Sample location (samples per location=9)</th>
<th>Total Plate Count ×10³</th>
<th>Total Coliform ×10²</th>
<th>E coli count ×10¹</th>
<th>Staphylococcus aureus spp ×10²</th>
<th>Salmonella spp ×10¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belvedere</td>
<td></td>
<td></td>
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<td>15-67</td>
<td>0-40</td>
<td>14-77</td>
<td>ND</td>
</tr>
<tr>
<td>Mean</td>
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<td>12.0</td>
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<td>0</td>
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<td>0</td>
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ND - Not detected in the sausage samples.
N - Number of samples (%) above the acceptable limit.

Figure 1. Mean of Total Aerobic Count in the street vended sausages collected from different locations

Suburbs had the highest mean counts and samples collected from Msasa recorded the least mean total aerobic counts. Figure 1.

Mean of total coliforms (×102) in the street vended sausages

The results indicate that all the samples collected were contaminated with coliforms. The coliforms are indicator organisms for hygiene and sanitary conditions. Samples collected from Budiriro Suburbs had the highest mean Total Coliforms. Table 1.

Mean of escherichia coli (×101) counts in the street vended sausages

Results are showing the mean E coli counts in the street vended sausages sampled. Samples collected from...
Figure 2. Mean of Total Coliforms of street vended sausages collected from different locations.

Budiriro Suburbs had the highest mean E coli counts and there was a slight difference between the mean of samples collected from Belvedere and Msasa Industrial Area. Figure 2.

Figure 3. Mean of E coli in the street vended sausages from different locations.

Mean of Staphylococcus aureus (×102) in the street vended sausages.

The results are showing the distribution of Staphylococcus aureus spp in the samples of sausages.
collected from different locations. The results indicates that samples collected from Budiriro samples had the highest number of Staphylococcus aureus isolates and samples collected from Msasa had the lowest isolates. Figure 3.

Mean of Salmonella spp (×101) in the street vended sausages.

The results are showing the trend of Salmonella spp distribution in samples of sausages collected from
different locations. Samples collected from Belvedere were not contaminated with Salmonella spp and there was highest Salmonella spp proliferation in samples collected from Budiriro Suburbs. Samples collected from Budiriro Suburbs had the highest recorded number of Salmonella spp followed by Copacabana and lastly Msasa Industrial Area. Figure 5.

**DISCUSSION**

The study was to conduct a microbiological assessment on cooked street vended sausages being sold in Harare areas, specifically in Belvedere (HIT), Budiriro Suburbs, Msasa Industrial Site and Copacabana Bus Terminus.

The results on the enumeration Total Aerobic Count in the street vended sausages ranged between 1.9×10^4 to 7.5×10^4 cfu/g for Belvedere, 1.7×10^4 to 5.3×10^4 cfu/g for Msasa Industrial Area, 1.8×10^4 to 1.02×10^5 cfu/g for samples collected from Copacabana Bus Terminus and 4.3×10^4 to 1.39×10^5 cfu/g for samples collected from Budiriro Suburbs. According to Gilbert et al. (2000), the standard or limit for the total microbial counts in ready-to-eat cooked foods under which sausages are categorised is <1×10^5 cfu/g. The results indicate that most sausage samples were within the acceptable microbiological quality except for two samples collected from Budiriro and Copacabana Bus Terminus which were above the standard limit. The lower microbial counts in some of the samples were attributed to the destruction of some of the microorganisms during cooking or heat treatment of the sausages carried out by the street food vendors before serving. As suggested by Gilbert et al. (2000), sausages are in category 2 type of food which refers to ready-to-eat foods in which all components of the food have been cooked in the manufacturing process or preparation of the final food product and as such microbial counts should be low. The higher microbial load in some of the cooked street vended sausages sampled from Budiriro Suburbs and Copacabana Bus Terminus might have resulted from insufficient cooking of the sausages coupled with purchasing heavily contaminated raw sausages, cross contamination of the sausages by the food vendor, improper post cooking handling and storage practices by the vendor whereby the sausages are not stored at the recommended holding temperatures of 60°C for food served hot or 7°C or below for food served cold as stipulated by the Codex Guidelines (1999), for ready-to-eat foods. Upon observation the sausages prepared by the vendors were left uncovered and this exposed the sausages to dust and flies which are carriers of microbial organisms hence this might have also contributed to the high microbial load in the sausages. According to Codex Guidelines (1999), storage of food or sausages inside the temperature danger zone area promotes microbial proliferation. Robert (2000), states that although heat treatment kills or reduces microorganisms to acceptable levels, inadequate storage of the food can result or increase contamination of the food with microorganisms. According to Mosupye and Von Holy (1999), the high microbial load in the samples above the acceptable limit is indicative of the presence of pathogenic microorganisms associated with health risks. However, Doyle (1991), states that it is possible to have low microbial loads in the cooked street vended sausages in which toxin producing organisms have grown.

The results on the enumeration of Total Coliforms for all the samples of cooked street vended sausages ranged from 13×10^3 cfu/g to 77×10^3 cfu/g. According to Gilbert et al. (2000), the limit for coliforms in foods is satisfactory for samples < 20 cfu/g and acceptable for samples with 20 to < 100 cfu/g. The results obtained from the microbial assay indicated that 19.4% of the sampled sausages were within the satisfactory limit indicating good microbiological quality. The results also revealed that 80.6% of the sampled sausages were in the acceptable limit. According to ICMSF (1980), microbial loads in the acceptable limits may indicate possible hygiene problems in the preparation of the food and the premises where the food is prepared should have their food handling controls investigated. Microbial results within the acceptable microbiological limits can present no food safety concern and signify good hygiene practices and handling practices. Upon observation, the street food vendors handled the foods under unsanitary conditions whilst exposing the sausages to storage temperature abuse and environmental contaminants. This implies that although the total coliform counts of the sampled sausages were within the acceptable limits, there was risk of microbial proliferation of the coliforms to levels above the acceptable limit of 100 to <10^4 cfu/g by the time of consumption of the sausages.

World Health Organisation (2006), states that coliforms are commonly used as bacterial indicators of sanitary quality of foods that is they indicate the presence of other disease causing bacteria. The presence of the coliforms although in low levels in the sausages may be indicative of the presence of disease causing microorganisms in the sausages. According to WHO (1989), total coliforms are bacteria that are found naturally in the environment and they are also indicative of faecal contamination. Although the coliforms present in the samples were within the acceptable range, their presence in cooked sausages foods may be indicative of poor post cooking handling practices, insufficient cooking and holding temperature abuse as the vendors keep the sausages at ambient temperatures. According to Robert (2000), coliforms are easily killed by heat and coliform counts can be useful when testing for post processing contamination. According to Codex (1999) the ready-to-eat foods must be held at 60°C or 7°C or below to suppress microbial growth.
According to Gilbert et al. (2000), the limit of total E coli of <200 cfu/g is satisfactory and 20 to <1000 cfu/g is within the acceptable limit. The results indicated that, E coli was detected in the street vended sausages sampled in the four different locations except for one sample collected from Msasa Industrial Area with the lowest range of 3×10^1 cfu/g to 40×10^1 cfu/g. The results indicated that the sausages were contaminated with fecal pollution. According to WHO (2006), E. coli is a coliform species found in the intestinal tract of warm-blooded animals its presence can be indicative of fresh pollution from human or animal waste. The highest level of E coli contamination was on a collected from Budiriro Suburbs. Upon observation this might have been due to the presence of a garbage dumping site nearby the vending site which attracted flies and the flies carried microorganisms onto the food as well as polluted dust from the garbage. The presence of E coli in most of the street vended sausages sampled indicated low observation of personal hygiene practices by the food handlers. According to Doyle (1991), to prevent E. coli from the garbage. The presence of E coli, compromises the microbiological quality of the sausages. The presence of E coli in some of the sausage samples might have been caused by the vendor handling food whilst suffering from E coli related diarrhoea. The consumption of the cooked street vended sausages could lead to acute or chronic food poisoning or food-borne illnesses such as gastroenteritis. Doyle (1999), states that although some strains of E coli are harmless there are some which include Enterohaemorrhagic E coli 0157:H7 that have been associated with traveller's diarrhoea, hence their presence poses a risk or harm to consumers. All samples were contaminated with S aureus. The colonies ranged from 11×10^2 cfu/g to 90×10^2 cfu/g. According to ICMSF (1980), the limits for Staphylococcus in foods are <200 cfu/g and 20 to <1000 cfu/g for satisfactory and acceptable limits respectively. The presence of S aureus implied that the street food vendors were not following good personnel hygiene practices. According to Gay (1982), the presence of S aureus in foods is largely as a result of human contamination that is from the human's respiratory passages, skin and superficial wounds on the human skin surfaces. Upon observation, most of the food vendors were using bare hands to handle and serve food, one of the vendors was identified to have traces of skin rash that had not fully recovered. According to Bennette and Lanette (2001), Staphylococcus is most commonly spread to others by contaminated hands. The street food vendors commonly do not wash their hands regularly especially when there are long queues of customers waiting to be served. Staphylococcus causes food poisoning when a food handler contaminates the food and the food is not properly refrigerated (Gay, 1982). These bacteria multiply quickly at ambient temperatures to produce toxins. According to Magnus (1981), the food vendors do not have proper storage facilities for raw, cooked and food leftovers and they normally place the cooked sausages in plastic containers at ambient temperatures for storage and for display purposes whilst it is waiting to be served to consumers. Salmonella was detected in some of the samples collected from Budiriro, Msasa Industrial Area and Copacabana. Samples collected from Belvedere did not show the presence of Salmonella. According to Doyle and Evans (1999), Salmonella must not be detected in foods. The presence of Salmonella in street vended foods can be attributed to undercooking, poor handling practices and cross contamination. The presence of the bacterium in the sampled sausages might have resulted from the street food vendors purchase already contaminated raw sausages from unregistered and unreliable suppliers who offer them with cheap substandard sausages produced under backyard or unregistered premises. According to Tauxe (1998), the bacteria can spread to humans via a variety of different foods of animal origin and food can be contaminated during food processing or food handling, by unwashed hands of an infected food handler especially one who does not frequently wash his or her hands. Due to the nature of the sausages they are highly susceptible to contamination with Salmonella spp and there are high chances that the sausages used by the vendors from the small scale producers are heavily contaminated and if not properly cooked, the microorganisms are not completely destroyed. Environmental contamination can also contribute to the presence of contamination street vended sausages. According to Prescott and Klein (2008), processed ready to eat foods contaminated with Salmonella spp even in small numbers results in such foods being of unacceptable quality or potentially hazardous. This implies that the sausages that were contaminated with Salmonella were not microbiologically fit for human consumption.

Statistically, there was significant difference (p< 0.05) in the microbiological loads of the cooked street vended sausages sampled from the different locations. The microbiological loads of the cooked street vended sausages were different amongst the four locations; this might have been due to the different sources of sausages of the vendors. The results indicated that most of the...
samples collected from Belvedere (HIT) had lower microbial counts when compared to samples collected from other locations. The difference might also have been due to the differences in the type of customers catered for by the vendors so it distinguishes their suppliers. Some vendors do not sufficiently cook the sausages to destroy microorganisms.

In conclusion, out of the thirty-six sausage samples analysed, the total aerobic count of thirty-four samples were within acceptable microbiological limits of <105 cfu/g, for total coliforms, E coli and S aureus all the samples were within the acceptable limits of <100 cfu/g. The presence of E coli, S aureus spp and Salmonella spp in the samples revealed hygiene problems amongst the street food vendors.

CONCLUSION AND RECOMMENDATIONS

CONCLUSION

The results of the study indicated that 5.6% of the cooked vended sausages that were sampled were outside the Total Aerobic Count acceptable limit. Samples collected from Budiriro recorded the highest Total Aerobic Counts, Total Coliforms, E coli, Staphylococcus aureus and Salmonella. All the sausage samples were within the acceptable limits in terms of Total Coliforms, E coli; Staphylococcus aureus spp. Salmonella spp was isolated in 38.8% of the total samples. The results indicate that the consumption of cooked street vended sausages can be associated with potential risk of foodborne illnesses as some samples collected had pathogenic microorganisms present hence this compromises the safety of the sausages.

The presence of microorganisms in the street vended sausages could be as a result of contamination from the environment which includes dust, flies. Poor food preparation due to insufficient cooking could have contributed to the presence of the microorganisms as the sausages are expected to have low microbial counts after the heat treatment. Poor personal hygiene and sanitation standards of some of the street food vendors are also another factor suspected to have introduced microorganisms to the vended sausages. The vendors might have not kept their foods at the recommended temperatures. In order to suppress microbial growth or proliferation, the vended sausages should be kept outside the temperature danger zone area between 5°C and 60°C such that harmful bacteria do not grow. The presence of these pathogens implied that there is potential hazard or risk of harm after consuming street vended sausages.

RECOMMENDATIONS

Policy makers should ensure that the street food vendors are educated on good hygiene practices and their implementation. This enhances prevention of incidences concerning food contamination and intoxication in foods and safeguard consumer health. Formal vending sites should be created for the street food vendors so that their activities can be easily monitored easily monitored by the responsible local authorities. Well defined infrastructure and working environments allows for the implementation of good manufacturing practices as well as food safety tools such as HACCP systems in the food vendors operations. Formal vending sites if established allow for the local authorities to regularly assess the food by inspecting the food to check for safety and also for easy enforcement of laws and regulations safeguarding the safety of food and the consumers. Awareness for both the consumer and the vendors should be carried out to ensure that everyone is aware of food safety issues.

In future, further studies need to include more parameters when carrying out microbiological assessment of street vended foods and the chemical analysis of the street vended foods should be studied to see if there are possible chemical hazards associated with the street vended foods.

REFERENCES