Review

Assessment of the microbial quality of raw chicken, mincemeat and sausage sold in selected informal markets in Harare's Western Suburbs, Zimbabwe

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ABSTRACT

Meat and meat products are important sources of protein in the human diet but are however potential vehicle for the transmission of food-borne diseases (FAO/WHO, 2013). The aim of the research was to assess the microbiological load of raw chicken, raw mincemeat and raw sausages sold on the informal markets in Harare, Zimbabwe through isolation, identification and enumeration of bacteria and fungi. A total of 90 Samples were collected from three different locations namely Mufakose, Machipisa and Mbare. The samples were analyzed for total bacterial (TBC), total coliforms (TCC), *Escherichia coli* (TEC) counts and the identification of bacteria and fungi using pour plating, culturing (streaking) and biochemical test according to standard operation procedures adopted from Markey *et al.,* (2013). The mean counts of TBC, TCC, TEC, ranged from 3.0×10^3 to 6.0×10^6, 1.0×10^2 to 1.0×10^6 and 3.0×10^1 to 1.0×10^6 respectively. A range of bacterial and fungal species were identified and their frequency rates were calculated. These are shown as follows: *Escherichia coli* (38%), *Staphylococcus aureus* (19%), *Klebseilla pneumoniae* (8%), *Proteus mirabilis* (3%), *Citrobactor* (1%), *Enterobacter species* (1%), *Enterococcus faecalis* (10%), and Coagulase negative Staphylococcus (1%) species were isolated. For fungi, *Aspergillus* species (12%) (*Aspergillus niger, Aspergillus fumigatus, Aspergillus flavus*), *Mucor* species (3%) and *Rhizopus* species (3%) were isolated. The results obtained showed that all of the samples analyzed were not conforming to the national regulatory standards. The high numbers of total bacteria count, coliforms and presence of *E. coli* indicate contamination thereby rendering the meat products not suitable for human consumption. From the results we concluded that chicken, minced meat and sausages sold in informal markets pose a high health risk to consumers.

Keywords: Microbiological load, informal markets and meat products

INTRODUCTION

Meat is a broad term used for the flesh of mammals and is usually consumed by humans and other carnivorous organisms (Adak *et al.,* 2005). Meat is an important source of protein in the human diet but is however a

potential vehicle for the transmission of food-borne diseases (FAO/WHO, 2013). It is one of the most perishable foods that potentially contain pathogenic bacteria that are harmful to humans hence it is a risk factor in the spread of bacteria and certain diseases that they cause. Several studies have been done worldwide on different kinds of raw meat purchased either at abattoirs or retail outlets with many objectives and most of these investigations have indicated the presence of bacteria in raw meat which raises concern over food safety (Yousef *et al.,* 2008).

Raw or unprocessed meat becomes spoilt after a few hours or days due to micro-organisms contamination like bacteria and fungi (Lonergan, 2005). Bacteria and fungi that are associated with meat spoilage acquired during slaughter, packaging, transportation or selling and handling include species of *Salmonella,* Shigella, Staphylococcus*, Streptococci,* Clostridium, Bacillus*, Proteus, Escherichia coli, Campylobacter*, *Penicillium, Mucor, Cladosporin, Sporotridium, and Thamnidium* and many others (Adak *et al.,* 2005, Clarence *et al.,* 2009; Stagnitta *et al.,* 2006). It is commonly suggested that microorganisms can enter meat preparation like mincemeat and sausages from meat, spices, and other ingredients, as well as from processing environment, equipment, and handlers that can have a significant impact on the microbiological status of the end-products and can be reduced by heating during technological processing (Gungor, 2010). When these microbes contaminate a piece of meat they start multiplying and some leaving behind toxins that cause food poisoning (Lonergan, 2005). Raw meat is thus an ecological niche for many genera of bacteria and fungi. Raw meat is an ideal growth medium for bacteria because it has high moisture contents, is rich in proteins and contains fermentable carbohydrates. Systematic inspection of meat (ante-mortems and post mortems) ensures that infected meat is completely eliminated hence consumers usually encounter these infections through exogenous spoilage of meat (Mboto et al., 2012).

Foodborne disease or microbiological spoilage of food can result from the failure or inability to control microorganisms at one or more stages of food production. Therefore, the microbiological testing at various stages of food production is relevant to reveal and understand the characteristic trends in distribution of microbiological contamination (Burlingame and Pineiro, 2007; ICMSF, 2011). Food borne diseases are diseases resulting from ingestion of bacteria, toxins and also cells produced by microorganisms present in food (Clarence *et al.,* 2009).The intensity of the signs and symptoms may vary with the amount of contaminated food ingested and susceptibility of the individuals to the toxin. Food borne illnesses have caused a number of morbidity and mortalities in Zimbabwe and World over.

Due to the current economic challenges in Zimbabwe most people cannot afford to buy meat in formal markets such as butcheries and supermarkets due to high prices which does not tally with their low incomes. At the same time, current high unemployment rates have resulted in many people resorting to informal trading which has seen them looking for different avenues that can generate income quickly. This has led to a lot of food vendors entering the informal meat markets and most people especially in high density suburbs have resorted to buying meat from them due to less pricing. Meat from food vendors is easily and readily available along roadsides and at local shops within walking distances close to people's households. The increasing sprouting of informal selling of meat and meat products in Harare suburbs and relaxation of the Public Health Act of Zimbabwe by the responsible authorities also put the public at risk. The Public Health Act of Zimbabwe prohibits the sale of meat and meat products by unregistered people or companies as it exposes the health of the public to foodborne illnesses and or diseases. The Act is not being implemented at the informal market and no law is being implied to the offenders. Only meat inspection and medical examinations are being done at the formal market but not at the informal market. There are no quality tests being done to informally produced mincemeat, chicken and sausages, which puts consumers at high risk as meat and meat products are the most common food source responsible for the outbreak of gastroenteritis illnesses. Hygiene conditions are poor when foods are produced in nonindustrial establishments, mainly due to insufficient monitoring during processing. In Harare, there are high incidences of these gastrointestinal illness (diarrhea), with several cases of typhoid fever and related illnesses being reported, as well as other areas in Zimbabwe where informal trading of this sort is being practiced. Very few incidences of foodborne illness are recorded and reported.

Informal markets are not fully equipped and have limited information and education on issues concerning hygienic practices. Unhygienic meat handling practices in the informal meat and meat products markets may contribute to unacceptable level of microbial loads in mincemeat, chicken and sausages. Some of the factors contributing to poor hygiene are lack infrastructure and services including lack of hand washing facilities, poor cleaning and lack of sterilization of mincemeat processing equipment and utensils, lack of cold storage, inappropriate transportation facilities, poor personal hygiene, shelter, toilets, water and garbage collection (Luccar and Forres, 2006). According to Muredzi et al., (2016), the state of the environmental surroundings of the place of operation of the street food vendors is a matter of concern. In all the three high density suburbs studied, all the informal marketers were selling their meat and meat products near garbage waste sites, 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 (Muredzi et al., 2016). Food safety at informal markets (suburbs and streets) has become one of the major concerns of public health around the world at large due to the increasing pace of globalisation and tourism (FDA, 2011). The danger in raw meat and products is that when packaged it may look palatable to the naked eye but might still contain pathogenic bacteria and fungi. It was against this background that the researchers carried out a microbial assessment of mincemeat, chicken and sausages sold in selected informal markets in Harare to find out the extent of food safety in our society. The aim of the research was to isolate, identify and enumerate bacteria and fungi in chicken, mincemeat and sausages sold on informal markets in Harare, Zimbabwe.

MATERIALS AND METHOD

Study design and sample sampling

The study design was a cross- sectional study and the sampling frame for this study was three informal retail outlets in three different places in Harare sampled randomly. The researchers first paid a visit to these selected areas namely Mufakose, Machipisa, and Mbare. Simple random sampling in combination with systematic sampling was applied in sample collection (Mboto *et.al,* 2012) whereby the vendors were first counted and only even numbers were sampled at each vending site and it was repeated thrice. The samples were collected in batches on three different days. Ten samples were purchased per batch, three from Mufakose (Vendor 1-3), three from Machipisa (Vendor 4-6) and then four from Mbare (Vendor 7-10). Four samples were collected from Mbare instead of three like other places because Mbare had the highest number of vending sites and vendors than the other two. It was repeated thrice to make the total number of 30 samples for mincemeat. The same was done for sausage and chicken to give a total combined sample size of 90. All samples were transported to CVL in an icebox and tested immediately upon arrival or stored at $4^{o}C$ for a maximum of 24 hours until they were analyzed.

General routine isolation and identification of bacteria

Five (5) grams of mincemeat, sausages and chicken were weighed and placed into 10mls of peptone water and incubated for 24hrs at 37˚C. After incubation a loopful of the mixture of the sample and peptone water was then streaked on Blood agar (BA) and MacConkey

agar (MAC) and was incubated aerobically and anaerobically at 37˚C for 24 hours (Markey et al., 2013). Incubated plates were taken out of the incubator the following day and plates were viewed for macroscopic (morphology) characteristics of the bacteria including haemolysis, shape, colour and elongation. Bacteria were identified according to morphology, gram staining and biochemical tests such as oxidase, catalase, motility, urease, citrate and indole.

Isolation and identification of *Salmonella spp*

Twenty five (25) grams of the mincemeat, chicken and sausages were weighed and placed in a 225ml pre-enrichment media which is Buffered Peptone Water (BPW) and incubated aerobically at 37˚C ±2˚C for 24 hours (Markey et al., 2013). After incubation, 1ml of the sample BPW mixture was transferred to an enrichment media which is Rappaport Vassiliadis (RV) and incubated aerobically at 37˚C ±2˚C for 24 hours. A loopful of the RV was sub-cultured on selective media Xylose Lysine Deoxycholate (XLD) agar and incubated aerobically at 37˚C ±2˚C for 24 hours (Markey et al., 2013). The XLD plates were examined for red or pink colonies with black centres (*Salmonella* suspects) (Markey et al., 2013). Biochemical tests were done and *Salmonella* Serotyping were performed on all the suspects (Markey et al., 2013).

Isolation of *Campylobacter spp*

Five (5) grams of each mincemeat, chicken and sausages were weighed and placed into 10mls of peptone water and incubated for 24hrs at 37˚C. After incubation a loopful on the mixture of the sample and peptone water was streaked on Blood agar (BA), Skirrows agar and *Campylobacter* agar and incubated anaerobically at 37˚C ±2˚C for up to 5days if there is no growth and *Campylobacte*r gas generating sachets were used to create the anaerobic conditions *(*Markey et al., 2013). Suspected colonies were done gram stain and a coma shaped or sigmoid shaped gram negative rods indicates *Campylobacter* and biochemical tests were done as on bacteria isolation

Detection of *Listeria species*

Twenty five (25) grams of mince, sausages and chicken were cut and placed in listeria selective broth and incubated for 24hours at 37ºC. After incubation, the broth was streaked on to listeria selective agar and incubated for 24hours at 37ºC (Markey et al., 2013). Biochemical tests such as motility, catalase, oxidase etc. on all the suspected colonies.

Bacteria identification

Bacteria identified using morphological characteristics such as colony colour, haemolysis, shape of colony and growth on MacConkey agar etc., gram stain, and biochemical tests such as indole, catalase, oxidase, motility etc. as well as fermentation of different sugars. Fig 1 below illustrates some of the biochemical tests performed inorder to identify the bacterial isolates presented in the results section.

Isolation and Identification of Fungi

One well labelled Sabouraud Dextrose Agar (SDA) plate was used for each meat and meat product sample. A small piece of the chicken, mincemeat and sausage was cut and was embedded using sterile forceps onto its respective SDA plate. After inoculation, the plates were incubated at 37°C for 1 to 5 days (Markey et al., 2013). Each day, changes were noted and recorded until the 5th day. Fungi were identified using their colonial morphology and microscopic appearance. Morphological charts from Clinical Veterinary Microbiology book was used to compare morphological features with the fungal species observed after incubation. Microscopic identification of the fungi were done using the sticky tape preparation technique according to Markey et al., (2013). A clear sellotape (6cm length by 2cm width) was taken between the thumb and middle finger, with the index finger in the centre of the loop that held the sticky side downwards (Markey et al., 2013). The adhesive side was pressed firmly down with the index finger on the centre of the colony to be examined. The fruiting heads and spores stuck to the tape and were gently pulled from the mat of the mycelium (Markey et al., 2013). The inoculated tape was placed over a drop of lactophenol blue on a microscope slide. The tape was pulled taut and the free sticky ends were folded over each end of the slide (Markey et al., 2013). The tape acted as a cover slip and the slides were examined under light microscope using power 10 and power 100 and photographs were taken.

Total Bacterial Count

Ten (10) grams of mincemeat, sausages and chicken were weighed in a clean labelled container and 90ml of phosphate buffered saline (PBS) and homogenized. 1ml of the homogenate was transferred into a 10^{-2} container with 9mls of PBS and mixed and again 1ml transferred to 10^{-3} up to 10^{-6} dilution series. 1ml was then transferred from each dilution series container into a respective labelled petri- dish. About 20ml of Plate Count Agar (PCA) was then poured and shaken and waited to solidify. When the plates solidify, they were then

incubated aerobically at 30˚C for 48-72hours. Counting of colonies in the highest dilution plate showing bacterial growth was done and results calculated and recorded. Only plates with 30-300 colonies were considered.

Total Coliform Counts

Ten (10) grams of mincemeat, chicken and sausages were weighed in a clean labelled container and 90ml of phosphate buffered saline (PBS) and homogenized. One (1) ml of the homogenate was transferred into a 10^{-2} container with 9mls of PBS and mixed and again 1ml transferred to 10^{-3} up to 10^{-6} dilution series. 1ml was then transferred from each dilution series container into a respective labelled petri- dish. About 20ml of MacConkey Agar (MA) was then poured and shaken and waited to solidify. When the plates solidify, they were then incubated aerobically at 37˚C for 24hours. Counting of pink colonies in the highest dilution plate showing bacterial growth was done and results calculated and recorded after performing biochemical tests to confirm them as coliforms which is motility, citrate and indole.

Total *E.coli* count

Ten (10) grams of mincemeat, chicken and sausages were weighed in a clean labelled container and 90ml of phosphate buffered saline (PBS) and homogenized. One (1) ml of the homogenate was transferred into a 10^{-2} container with 9mls of PBS and mixed and again 1ml transferred to 10^{-3} up to 10^{-6} dilution series. 1ml was then transferred from each dilution series container into a respective labelled petri- dish. About 20ml of MacConkey Agar (MA) was then poured and shaken and waited to solidify. When the plates solidify, they were then incubated aerobically at 44˚C for 24hours. Counting of pink colonies in the highest dilution plate showing bacterial growth was done and results calculated and recorded after performing biochemical tests to confirm them as coliforms which is motility, citrate and indole.

Positive and negative control was processed parallel with the samples and results will be regarded when positive controls grow and negative control does not show any growth. The media were prepared according to manufacturer's instructions.

Calculation of results

The number of colonies was multiplied by the dilution factor and divided by weight of sample and reported as the number of organism per gram of food. Since not all cells grow with any one particular set of conditions, the count was referred to as colony forming units (CFU) per
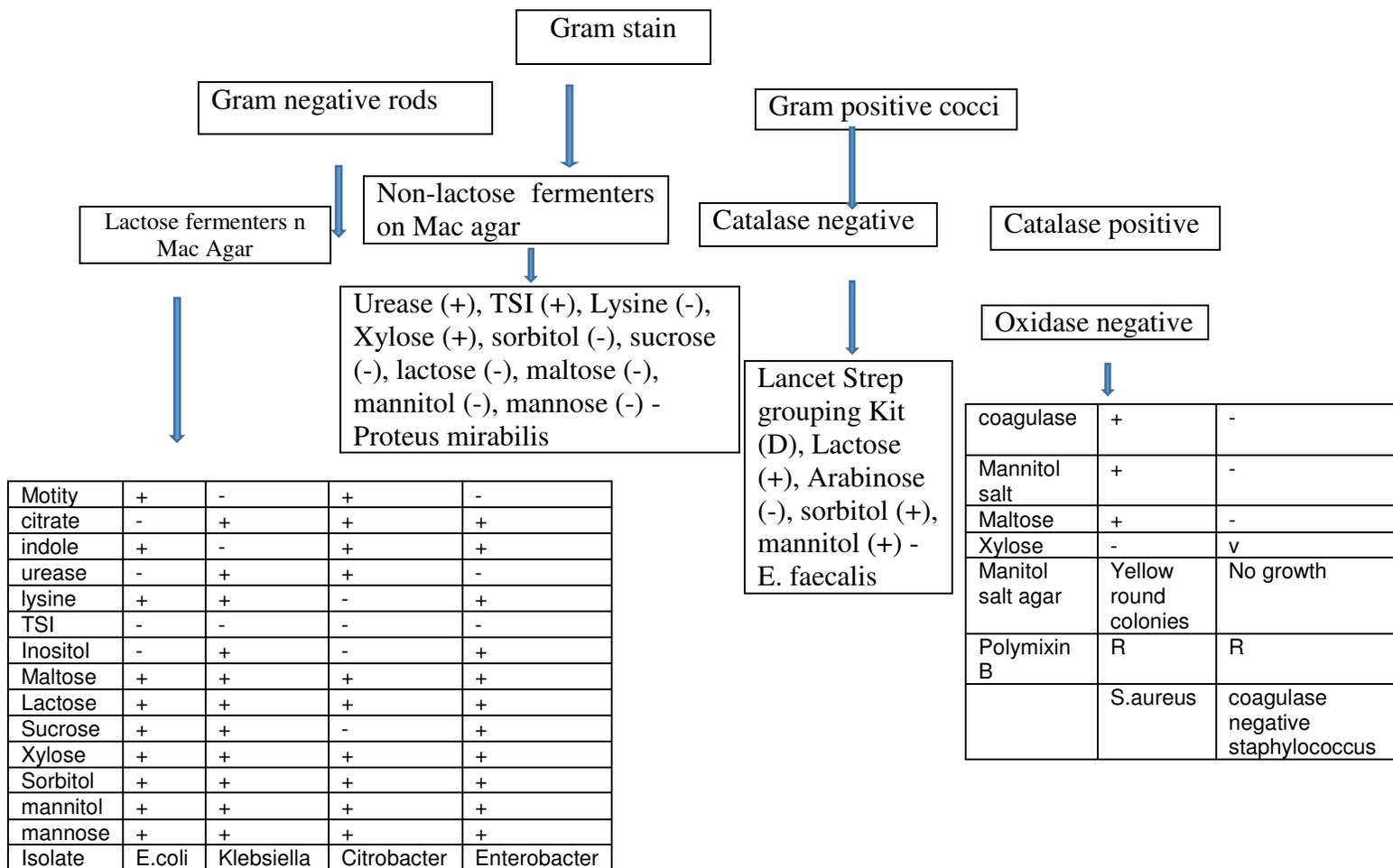
Figure 1. Flow diagram showing some biochemical tests used to identify different bacterial isolates

gram of food (sample) (Vanderzant and Splittstoesser, 1992).

Formula

Number of colonies × reciprocal dilution factor x amount used = Colony forming unit (CFU) per gram of sample
e.g. TBC 20 colonies on 10^{-2}
20 x 100 x 1= 2, 0 x 10^3 cfu/g

RESULTS

Bacterial Isolation

After incubation all the media were removed from the incubators and the morphological appearance of the bacterial colonies were observed and recorded. Gram stain and a series of biochemical tests were performed as indicated in figure 1.

The colonies suspected to be E.coli on Blood agar were round raised grey showing Beta haemolysis/Alpha haemolysis colonies and on MacConkey agar they were round raised shiny pink colonies. The colonies that were suspected to be Staphylococcus species on Blood agar were round raised medium sized yellow/white/grey showing Beta haemolysis and were round medium sized pink colonies on MacConkey. Colonies suspected to be Klebsiella species on Blood agar were grey mucoid shiny colonies and on MacConkey were mucoid late lactose fermenters. Citrobacter suspected colonies were shiny round grey Alpha haemolytic colonies on Blood agar and round shiny raised pink colonies on MacConkey agar. Grey swarming colonies on Blood agar and round raised pale colonies on MacConkey was suspected as Proteus species. Enterobacter species were grey mucoid on Blood agar and pink round mucoid colonies on

Table 1. Number of times the isolates detected and their frequency rates.

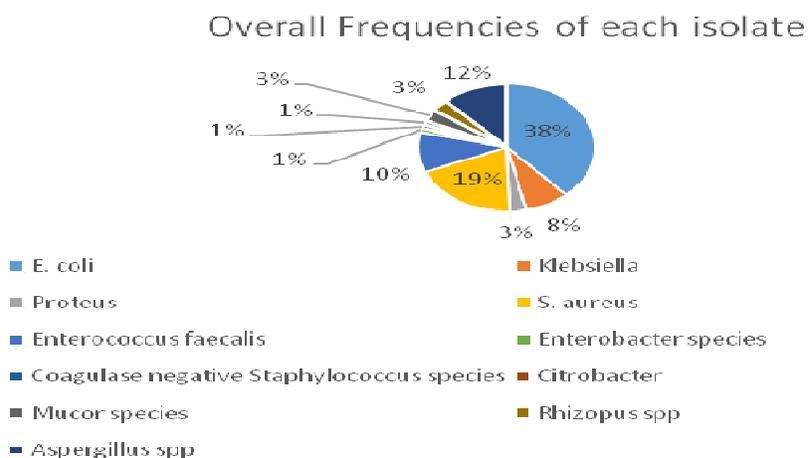| Microbes isolated	Number of times the isolates detected			Total	Overall Frequencies of each isolate
	mincemeat	chicken	Sausage		
E. coli	22	20	18	60	38%
Klebsiella	4	5	4	13	8%
Proteus	2	0	3	5	3%
S. aureus	9	10	11	30	19%
Enterococcus faecalis	5	5	6	16	10%
Enterobacter species	1	1	0	2	1%
Coagulase negative Staphylococcus species	1	0	1	2	1%
Citrobacter	1	0	0	1	1%
Mucor species	3	1	1	5	3%
Rhizopus spp	3	1	1	5	3%
Aspergillus spp	9	6	4	19	12%
total				158	

Figure 2. Overall prevalence rates of suspected bacteria and fungi on all sample types

MacConkey agar. Tiny round grey shiny colonies on blood agar and tiny pink colonies on MacConkey agar were suspected as Streptococci species. Gram stain was performed on all the suspected colonies and the gram stain results were used to guide us on the next biochemical tests to perform. Morphological characteristics, gram stain and biochemical tests were used to identify the bacteria. Gram negative bacilli (rod shaped) and gram positive cocci were identified. The biochemical test results and gram stain results are indicated on the flow diagram (Figure 1) below. Isolated bacteria in various samples were suspected to be *S. aureus, E. coli, Klebsiella* spp., *Citrobacter* species, *Enterobacter* species, *Proteus mirabilis* and *Enterococcus faecalis*. Fungi isolated were suspected to be Mucor species, Rhizopus species and Aspergillus species. Fungi was identified using morphological and microscopic characteristics. The number of bacteria and fungi isolated from the three meat products are shown in figure 1.

Frequency of isolated bacteria and fungi

The frequencies of isolated bacteria and fungi were expressed as overall percentage prevalence from all sample type i.e. Chicken, Sausage and Mincemeat as shown in figure 2. *E. coli* had the highest frequency (38%) followed by *S. aureus* (19%) and *Aspergillus* species (12%). Some organisms such as *Citrobacter*, Coagulase negative Staphylococcus species and Enterobacter species have 1% prevalence rate, Enterococcus faecalis 10%, Klebsiella 8%, Proteus 3%, Muccor 3% and Rhizopas 3%. Table 1 shows the number of times bacterial and fungal isolates were detected and their prevalence rates whilst figure 2 below shows the overall prevalence rates for all the isolated microbes. In terms of the number of times the bacterial and fungal isolates detected in type of meat and meat products, mincemeat have the highest number of isolates compared to the others.
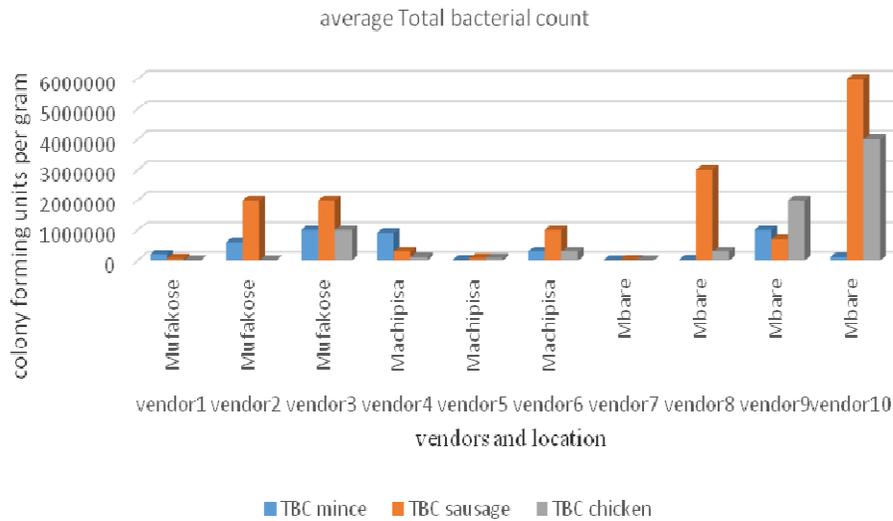
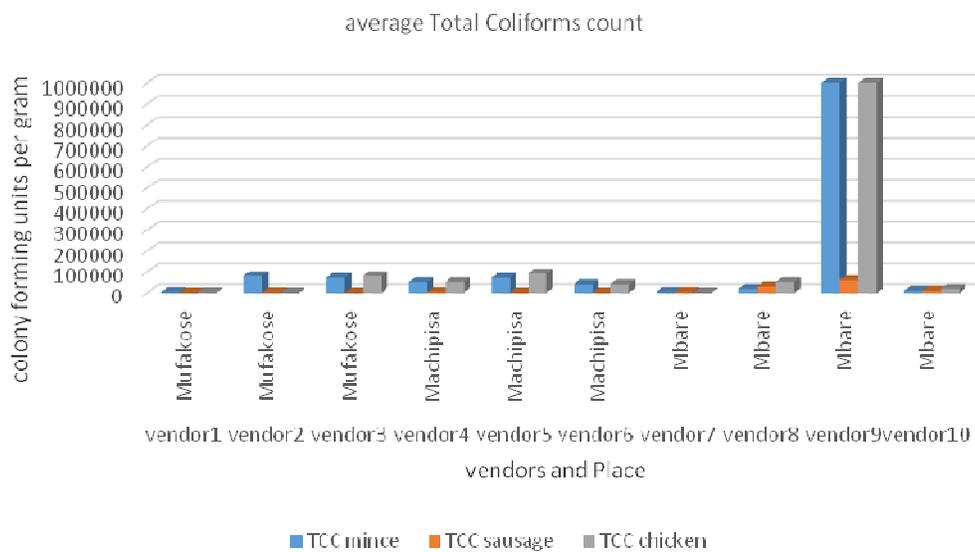**Figure 3.** Average total viable counts on meat products

Figure 4. Average total coliform counts on meat products.

Total viable bacteria count (TBC)

The positive control had a Total Bacteria Count (TBC) of 7.8×10^6 cfu/ml and negative control had no growth. Mean TBC of all the three meat products and the three locations are shown in figure. 3 below whereby sausages have the highest number of TBCs especially in Mbare followed by chicken then mincemeat. Some of the TBC of the three meat products were within the recommended TBC of less than $1.0 \times 10^{\wedge}6$ except for sausages from vendor 10 in Mbare, Vendor 8 in Mbare, vendor 2 in Mufakose, and vendor 3 in Mufakose and chicken from vendor 10 in Mbare, vendor 9 in Mbare, which have mean TBC values of greater than $1.0 \times 10^{\wedge}6$ and are no

safe for human consumption. Average total bacterial count for sausages, mincemeat and chicken ranged from 1.0×10^4 to 6.0×10^6, 4.0×10^3 to 1.0×10^6 and 2.0×10^3 to 4.0×10^6 respectively. Average total bacterial counts were above recommended standard of $<1.0 \times 10^6$ for 50% of the sausages tested, 30% of the mincemeat and 30% of the chicken tested.

Total coliform count (TCC)

Mean TCC of all the three meat products and the three locations are shown in figure 4 below whereby chicken and mincemeat have the highest average TCC of 1.0 x
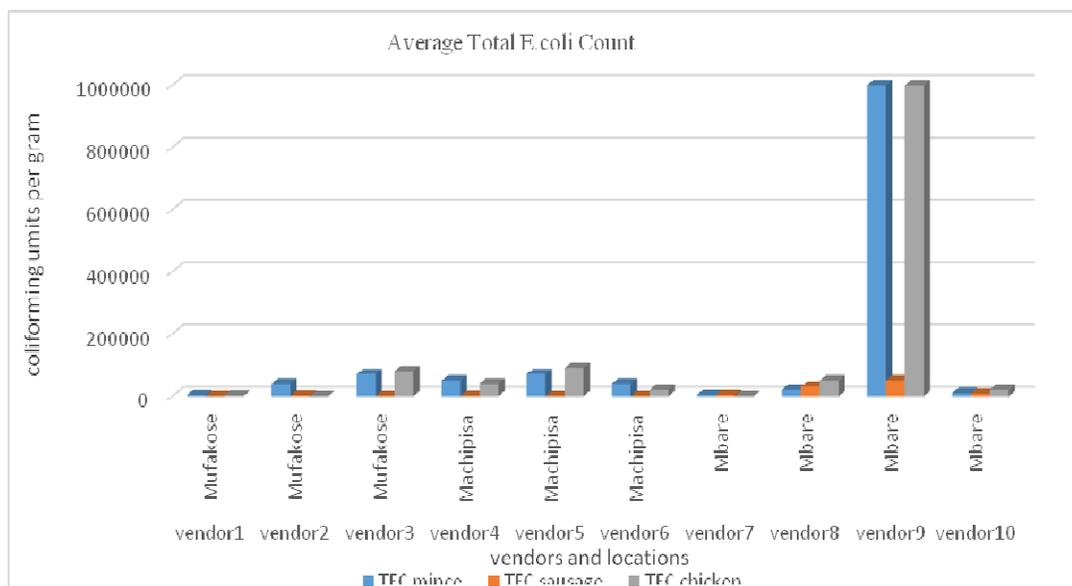
Figure 5. Average total *E.coli* counts on meat products.

10^6 in Mbare (Vendor 9). None of the TCC of the three meat products were within the recommended TCC of less than 1.0×10^2 and are not safe for human consumption. Average TCC for sausages, mincemeat and chicken ranged from 1.0×10^2 to 6.0×10^4, 3.0×10^3 to 1.0×10^6 and 2.0×10^2 to 1.0×10^6 respectively. Vendor nine shows the highest average total coliform counts.

Total E.coli count (TEC)

Mean TEC of all the three meat products and the three locations are shown in figure 5 below whereby chicken and mincemeat have the highest average TCC of 1.0×10^6 in Mbare (Vendor 9). None of the average TEC of the three meat products were within the recommended TEC of $<1.0 \times 10^1$ and are no safe for human consumption. Average TEC for sausages, mincemeat and chicken ranged from 3.0×10^1 to 5.0×10^4, 3.0×10^3 to 1.0×10^6 and 1.0×10^2 to 4.0×10^6 respectively.

DISCUSSION

Opportunistic pathogenic bacteria isolated from chicken, mincemeat and sausages were suspected to be *Staphylococcus aureus, Escherichia coli, Klebsiella pneumoniae, Proteus mirabilis, Citrobacter, Enterobacter* and *Enterococcus faecalis.* The results were in agreement with other findings such as the research results on mincemeat sold in Turkey which were found to be heavily contaminated with a variety of microorganisms and they contain pathogens that may cause infection and intoxications that could be seriously hazardous for public

health (Kimiran-Erdem, 2014; Siriken, 2004).

E. coli, Klebsiella pneumoniae, Citrobacter and Enterobacter are coliforms and their presence in any food sample reflects faecal contamination hence they should not be isolated in food samples (Stiles and La, 1981).

The presence of coliforms serves as an indication of faecal contamination due to poor sanitary conditions and unhygienic handling of meat during processing or the apparatus used, which is materials, equipment and personnel, packaging and selling (Schaffner, 2007)). The results above shows that vendors are also responsible for contamination of meat products considering the fact that all the vendors might have gotten their products from same supplier but microbial contamination of their product are different. *E. coli* shows to be dominant as most samples were contaminated with it. Vendors and the selling environments also plays an important role in causing contamination. In this research the biggest possible source of contamination are vendors through the handling of meat products during packaging, absence of proper sanitary wear such as hair covering and lack of proper storage facilities of meat products during and after processing. Storing meat products at room temperature may increase microbial growth and alter the chemical state of the meat (Codex Guidelines, 1999, USDA, 2O15).

Vendors at Machipisa were located near public toilets at the commuter terminus. The toilets generally have poor hygienic standards. It is therefore suspected that they could be the source of contamination of the meat or the use of contaminated water. Another source of contamination could be improper and unhygienic slaughter of the animals. Therefore the pathogens found in the environment, intestines and faeces of animals can

contaminate the rest of the meat. *E. coli* had the highest frequency of the isolated bacteria in all the meat products tested. According to USDA (2015), *E. coli* is of particular concern in ground meat, especially the shiga-toxin producing strain *E. coli* 0157:H7. Grinding of meat and mixing of ingredients increases the surface area for contamination (USDA, 2015). It is also psychrotrophic and will survive even if the meat is refrigerated (Moyer and Morita, 2007). In some samples *E. coli* was observed to be β haemolytic on Blood agar. This *E. coli* was suspected to be the shiga-toxin producing strain (*E. coli* 0157:H7) which is pathogenic and fatal in serious cases. However this could not be confirmed due to limitations in laboratory resources.

Staphylococcus aureus and *Enterococcus faecalis* are usually found on the skin, infected cuts, pimples, wounds and on the nose together with associated body fluids such as mucus and sputum. The presence of these pathogens in retail meat is an indicator of unhygienic handling of the meat either during slaughter, packaging or retail. These pathogens produce toxins when they multiply which cause gastro-intestinal illnesses (CDC, 2015). *S. faecalis* also is an indicative of faecal contamination and its presence means the mincemeat, sausages and chicken were contaminated and not suitable for human consumption. In another study conducted in Ankara-Turkey, *S. aureus* were isolated from 14 out of 30 ground beef samples (Gundogan et al., 2005). When the number of *S. aureus* bacteria exceeds 10^5 cfu/g sample, toxin production potential also increases. Although the number of contaminating *S. aureus* may be very low, under the favourable conditions, particularly at storage conditions above 6°C, bacteria quickly reproduce and begin synthesizing enterotoxins, causing possible food poisonings.

Presence of *Proteus mirabilis* is also an indication of faecal contamination of the meat products. All the bacteria isolated are opportunistic pathogens that cause disease in immune-compromised personnel. All the samples were safe from *Campylobacter jejuni* and *Salmonella*. In previous studies *Campylobacter jejuni* was not detected in any food sample. It has been significantly associated with the consumption or handling of raw or uncooked poultry, meats, raw milk and surface water.

Aspergillus niger, Aspergillus flavus, Aspergillus fumigatus, Rhizopus species and *Mucor* species are environmental fungi and can only cause disease only in immune-supressed individuals. The presence of *Aspergillus flavus*, which is associated with the production of hazardous mycotoxins called aflatoxins may pose a high risk to humans consuming the meat products contaminated with the aflatoxins (which may cause emerging infectious disease with no cure are on the rise such as cancer).

The mean TBC, TCC, and TEC ranged from 5.0 x 10^3 to 6.0 x 10^6, 1.0 x 10^2 to 1.0 x 10^6 and 3.0 x 10^1 to 1.0 x 10^6 respectively. The mean TBC of vendor three (Mufakose) and vendor nine (Mbare) were above the conforming standards and show that the meat products were heavily contaminated (microbial load) compared to other vendors, this might be caused by poor handling during packaging and storage. This also shows that the vendors have a greater risk of posing a health hazard to the public. Most vendors might handle their meat without any protective clothing or washing their hands and the meat they sell might not be from reliable sources. Some samples from some vendors were above the permissible bacterial load, which in Zimbabwe TBC must be <1×10^6. High TBC counts greater than 1×10^6 is an indication of the existence of pathogenic microbes associated with health threats. These vendors were located inside the rank and at shopping centres where there is the most congestion and hyperactivity. Selling meat and meat products to the public is automatically a health hazard because the meat products were not fit for human consumption. Therefore it is assumed that the sanitary level of the study area generally influenced the bacterial loads regardless of the place.

Recommended total coliform counts should be ≤1×10^2 and in this research it was found that all the samples have more counts and therefore considered not suitable for human consumption. Coliforms count is a reliable indicator of inadequate processing and post processing contamination of such products (ICMSF, 1996). In addition, coliforms in processed meat may be responsible for inferior quality resulting in economic losses beside their presence in high count may give rise to public health hazard. Total *E. coli* count were present in all the samples and the samples are condemned because they are faecal contaminated because TEC should be zero. Previous studies done by other researchers also support our findings. A number of studies reported total bacteria counts, *Staphylococci*, coliform bacteria and *E. coli* in meat and meat products samples to be above the standard recommendations. These high counts show contamination of the analysed samples and is in line with our findings.

CONCLUSION

From the findings of this research it showed that all samples were heavily contaminated and cannot meet the set standards on total bacterial count, coliforms, *E. coli* and fungi/yeast. The obtained results and the discussion shows that the mincemeat, sausages and chicken sold from informal markets are not suitable for human consumption. The presence of haemolytic *E.coli* in mincemeat, sausages and chicken, showed that consumers are at risk of foodborne illness as this microorganism are termed to be highly pathogenic and can cause acute illness. The results indicate that there is

need for good hygienic practices to be practiced by vendors during food handling, packaging, selling and storage to lower the TBC, TCC and TEC to acceptable recommended standards.

RECOMMENDATIONS

- The Harare City Council public health inspectors should perform thorough routine checks of meat at retail stores and close down those that do not conform to required standards.
- The Harare City Council should also aim at removing illegal vendors, especially those selling perishable foods such as meat as they pose a serious health hazard to the society.
- Awareness campaigns should be held to educate the people of Harare on the health hazards posed by buying and consuming meat and meat products from vendors as most of it is not safe for human consumption.
- Good hygienic practices need to be upheld in meat throughout all stages of its production, processing and preparation to protect the health of the consumers. The competent authorities need to effect official controls that include inspections and certification of meat for food safety assurance. Uninspected meat and meat products should not be allowed at all onto the food market.
- The public must value ethics and morals and demand safe inspected meat at a cost that they can afford, and government can create an environment where the inspection of meat does not substantially increase the cost of production of the product such as to deter the practice. Ultimately, no uninspected meat should be found in both the formal and informal markets.
- Proper sanitation must be possible at any markets where food is sold; achieved by keeping retail outlets as clean as possible, disinfection of hands at all times as well as wearing protective clothing.
- An adequate and clean water supply must be provided for butcheries and meat suppliers so as to avoid contamination of the meat at packaging and retail levels, and work surfaces must be disinfected at regular intervals.
- Consumers need to uphold thorough cooking of meat as most pathogens are eliminated by heat and as such, food poisoning incidents can be reduced.
- The study results should trigger further research throughout the country so as to generate adequate statistical data on the foodborne illness among Zimbabweans. Food-borne bacteria has been a major cause for concern on both food borne infections and intoxication in Zimbabwe and further research is recommended. This study should also

strengthen efforts to implement the 'One Health' concept in Zimbabwe where Veterinary and Health authorities work together for the common good in terms of research, regulation as well as implementation of the Public Health Act.

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