Microbial Analysis and Assessment of Heavy Metals of Selected Fresh Meat Samples in Kontagora Local Government Area of Niger State, Nigeria

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ABSTRACT

This study assessed and analysed microbes and heavy metals in fresh raw meat (heart, stripes, liver and kidney) of cow, goat and ram from abattoirs and retail stalls in Kawo and Kontagora, Niger State, to ensure safety and quality of meat products. Meat, a good source of basic nutrients needed by the body, is influenced by the level of its nutritive value, pH, water, temperature, storage and processing methods, which predispose it to microorganism's growth and heavy metals presence. Parts of beef, chevon and mutton (n = 48) were randomly selected and collected at every visitation, into sterile polythene bags with ice packs and transported to the laboratory for microbiological and heavy metals analyses. Micro-organisms analyses were carried out using nutritive MacConkey, Mannitol salt, Salmonella–Shigella (SS) and Potato dextrose agar as standard procedures for enumeration and identification. Laboratory quality control procedures were ensured. The total viable counts of meat samples showed microbial contamination. The overall mean microbial load (TBC) was between 36.0 – 42.5 x 10^{2} cfu/g and 14.25 – 15.5 x 10^{2} cfu/g for meat sampled in Kawo and Kontagora respectively. TCC was at 6.5 – 16.25 x 10^{2} cfu/g in Kawo and 2.0 – 7.0 x 10^{2} cfu/g in Kontagora. The TBC in sampled meat from Kawo was significantly higher than Kontagora. A total of 12 isolates belonging to 8 genera were identified, including *Staphylococcus aureus*, which was dominant in both locations (18.51 %). *Salmonella typhi* isolate was similar (3.7 %) for both locations. The meat parts studied revealed the presence of all the heavy metals examined in the range 0.00 – 120.96 mg/kg irrespective of sampling location and meat parts. Zn in cow heart and tripe, Cu in cow tripe and Mn in all the cow parts were below detection while Fe recorded the highest concentrations (84.11 – 120.96 mg/kg), followed by Mn (0.00 – 1.70 mg/kg) in all meat samples. Pb, Cd, Zn, Cu, Cr and Ni recorded values < 1.00 mg/kg. All meat samples showed microbial contamination within the satisfactory and borderline levels as well as heavy metals levels below the recommended allowable limits set by the standard organisations. Among others, it is recommended that abattoir practices and meats from retail stalls should be regularly monitored to ameliorate meat safety for public consumption.

Keywords: Microbial load, Meat, Heavy metals, Food safety, Micro-organisms.

INTRODUCTION

Meat as commonly known includes various animal organs and carcass that are regarded as edible, and varies among countries, beliefs and individuals. Meat plays a dietary role by providing the body with high-quality proteins, essential minerals and trace elements, vitamins for growth, repairs and maintenance of body cells for everyday activities [1].

In Nigeria, meat producing animals such as cow, goat, ram and others are grazed through nomadic system during which they eat grasses in the surroundings and also drink water from any nearby water body including stagnant water, which could have been contaminated with microorganisms and heavy metals [2, 3].

Meat has a high nutritive value and it is perishable with short life span due to microorganisms' growth. Meat could be sterile before slaughter but some degree of contamination may occur due to the conditions of the abattoirs and handlers [4]. The possible sources of contamination are through slaughtering of sick/diseased animals, which could take place under unhygienic conditions coupled with high temperature (applicable in the Northern part of Nigeria), high humidity, washing with dirty water due to shortage of clean water, poor and unhygienic handling by butchers, contamination by flies, processing close to water bodies contaminated by sewage and refuse dumps, use of contaminated equipment, utensils, other surfaces and transportation [5]. According to Iwuagwu *et al*. [6], bacterial isolates in meat include *Staphylococcus spp, Klebsiella*, *Enterococcus spp, Salmonella spp*, Campylobacter and a host of others. This can be obtained by the Total viable bacterial count (TVBC), which indicates poor quality of meat and Coliform count (CC), which defines wastes and faecal contamination.

Heavy metal contamination in meat samples is a pressing concern, requiring concerted efforts from all and sundry. In Nigeria, meat producing animals such as cow, goat, ram and others are grazed through nomadic system, during which they eat grasses in the surroundings and also drink from any nearby water body including stagnant water, which could have been contaminated with heavy metals [2]. Contamination with heavy metal is a serious health threat because of their non-biodegradability, bioaccumulation and bio-magnifications in the food chain, which makes them toxic even at minute concentrations.

Soil is a major receptor of pollutants such as heavy metals from natural, industrial, agricultural and anthropogenic activities. Most pollutants are retained in the soil through natural activities, causing some degree of harm to the soil ecosystem [7]. Plants grown on contaminated soil get contaminated alongside the animals which feed on them, and humans who in turn feed on such animal's meat stand a chance of being contaminated with the bio-accumulating heavy metal. Other sources of heavy metals include the air through respiratory system [8].

Essential heavy metals like copper (Cu), cobalt (Co), iron (Fe), zinc (Zn) and magnesium (Mg) have important functions in human metabolism but their deficiency and excessiveness have been associated with serious metabolic disorder. Non-essential heavy metals such as lead (Pb), cadmium (Cd), mercury (Hg), chromium (Cr), nickel (Ni) and arsenic (As), at low concentrations, can cause profound biochemical and neurological changes in the body [9]. Generally, environmental sources including the soil, water, air, feed and secondary sources such as handling and processing practices are largely responsible for heavy metals contamination in animals [10, 1]

This study, therefore focuses on the isolation, identification, assessment of microorganisms and evaluation of heavy metal levels in the meat samples (heart, tripe, liver and kidney) from cow, goat and ram slaughtered in Kawo and Kontagora abattoirs and retail stalls. These become necessary so as to promote safer meat consumption in the region.

METHODS

Sampling Areas

Kawo is a rural community situated within the Kontagora Local Government Area (LGA) of Niger state. It is known to host a major rural market every Sunday. A simple random sampling was used to collect raw meat samples from abattoirs and retail stalls in Kawo and Kontagora markets in Kontagora LGA. The samples collected were liver, meat, stripes and kidney each of cow, goat, and ram from the two locations.

Samples Collection

A total of 48 samples of different parts (heart, stripe, kidney and liver) of 100 g each of ram, goat and cow meat was collected from the abattoirs and local market stalls in Kawo and Kontagora. The samples were aseptically collected into labelled sterile polythene bags, sealed and transported in ice packs to the laboratory for microbiological and heavy metal analysis.

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Samples Preparation for Microbial Analysis

Collected samples were trimmed with sterilized steel knife and analysis was made according to the standard procedures/guidelines. 10.0 g of each of the samples were weighed and taken into a jar containing 90 cm^3 sterile normal saline and homogenized with sterile blender at 3000 rpm for about 10 minutes. 1 cm^3 aliquot of the homogenate was transferred to a test tube containing 9 cm^3 of sterile water to make a ten-fold series of dilution and shaken vigorously. Sterile dilutions were performed up to 10^2 and samples prepared in triplicates using pour plate method for the microbial analysis. 1 cm^3 of sterile Inoculum was spread uniformly into each sterile petri dish for countable colonies and plated on different media for microbial growth and enumeration at incubation.

Samples Preparation for Heavy Metal Analysis

For heavy metals analysis, 1 g of meat sample was weighted into a 100 cm^3 acid washed flask which was rinsed with distilled water. Acid digestion with 4 cm^3 concentrated Perchloric acid, 10 cm^3 concentrated Nitric acid and 2 cm^3 sulphuric acid was carried out at 550^{o}C on a hot plate. Heating continued until white dense fume was observed. The digested solution was analysed with Atomic Absorption Spectrophotometer (AAS).

Analytical procedures

Microbiological Analysis

Total Bacterial Count (TBC)

A volume of 1 cm^3 aliquots from the previously prepared dilutions were transferred to sterile petri plates of molten nutrient agar and allowed to settle evenly by slightly rotating the plates. The media was allowed to solidify, inverted and incubated at 25^{o}C for 72 hours. Colonies of white spots was counted after incubation, multiplied by the reciprocal of the specific dilution factor and expressed as Colony forming unit/gram (cfu/g) [11].

Total Coliform Count (TCC)

A portion of 1 cm^3 aliquot from each of the previous dilution preparations was inoculated into triplicates of 9 cm^3 sterile MacConkey agar broth tubes, which was allowed to dry at room temperature for 15 minutes. The plates were inverted, incubated at about 37^{o}C for 36 hours and slightly agitated. These broth tubes were examined for gas and colour change from violet to yellow [12]

Detection for Salmonella

Mass 25 g of meat samples each was weighed aseptically into sterile homogenizer flasks containing 225 cm^3 diluent of 1 % sterile peptone water, incubated at 37^{o}C for 24 hours and 1 cm^3 was aseptically inoculated into 1 cm^3 of Rappaport vassiliadis broth tubes in triplicates and thoroughly mixed with Salmonella–Shigella (SS) agar before incubation at 44^{o}C for 48 hours. Suspected colonies of non-lactose fermenters on the SS agar indicate the presence of Salmonella.

Identification of Staphylococcus species

Some 1 cm^3 aliquots of the previously serial dilutions was inoculated into triplicate petri dishes of already prepared Mannitol Salt agar. The inoculum was evenly spread and allowed to dry at room temperature for 15 minutes. The plates were inverted and incubated at 37 ^{0}C for 24 hours. The growth was examined for colonial morphology. Yellow colonies surrounded by clear zones were counted and recorded as counts for Staphylococcus.

Determination of Total Coliform Count

A volume 10 cm^3 from the previously prepared serial dilutions was aseptically transferred into separate sterile plates of approximately 15 cm^3 of melted and tempered violet red bile glucose agar media (VRBG) was added.

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After solidification, the thin layer of the VRBG was layered and the plates incubated at 37^0C for 36 hours. All purple colonies surrounded by a purple zone were counted and average taken at cfu/g

Total Fungal Count

Some 0.1 cm^3 of previously serial dilution was transferred into plate with sterile Potato Dextrose Agar (PDA) of pH 3.5 with tartaric acid. The plate was shaken gently to mix the content properly and then allowed to settle. Thereafter, incubated at 37^0C for 4 hours. After incubation, the revealing colony was counted and expressed as cfu/g.

Heavy metal analysis

In the laboratory, the meat samples were sliced, oven dried and homogenized after pulverization. 1 g of pulverised and sieved meat sample was weighted into a 100 cm^3 acid washed flask which was rinsed with distilled water. Acid digestion with 4 cm^3 concentrated Perchloric acid, 10 cm^3 concentrated Nitric acid and 2 cm^3 sulphuric acid was carried out at 550 ^{0}C on a hot plate. Heating continued until white dense fume was observed. The digested solution was analysed with Atomic Absorption Spectrophotometer (AAS)- AAanalyst 200.

RESULTS

The results obtained from microbial analysis are as shown in Table 1 and Figure 1:

Table 1: Mean ± S.D. of Microbiological Analysis of Meat Samples at 10^2 cfu/g

Meat Samples	Chevon	Mutton	Beef	Chevon	Mutton	Beef
Microbiological Parameters		**Kawo**			**Kontagora**	
TBC	42.50±17.02	36.0±18.81	36.75±23.70	15.5±7.57	15.5±.6.47	14.25±7.79
TCC	16.25±10.11	11.25±7.45	6.50±6.30	5.75±4.02	7.00±3.85	2.00±2.00
TSAC	8.50±9.87	4.23±1.41	3.00±4.34	2.50±1.60	1.78±0.46	1.50±1.60
TSSC	0.50±0.80	0	1.50±2.41	0.50±0.53	0.50±0.53	1.00±1.30
TFC	5.25±2.43	3.50±2.18	4.50±5.20	2.00±1.07	1.00±1.07	2.00±1.07

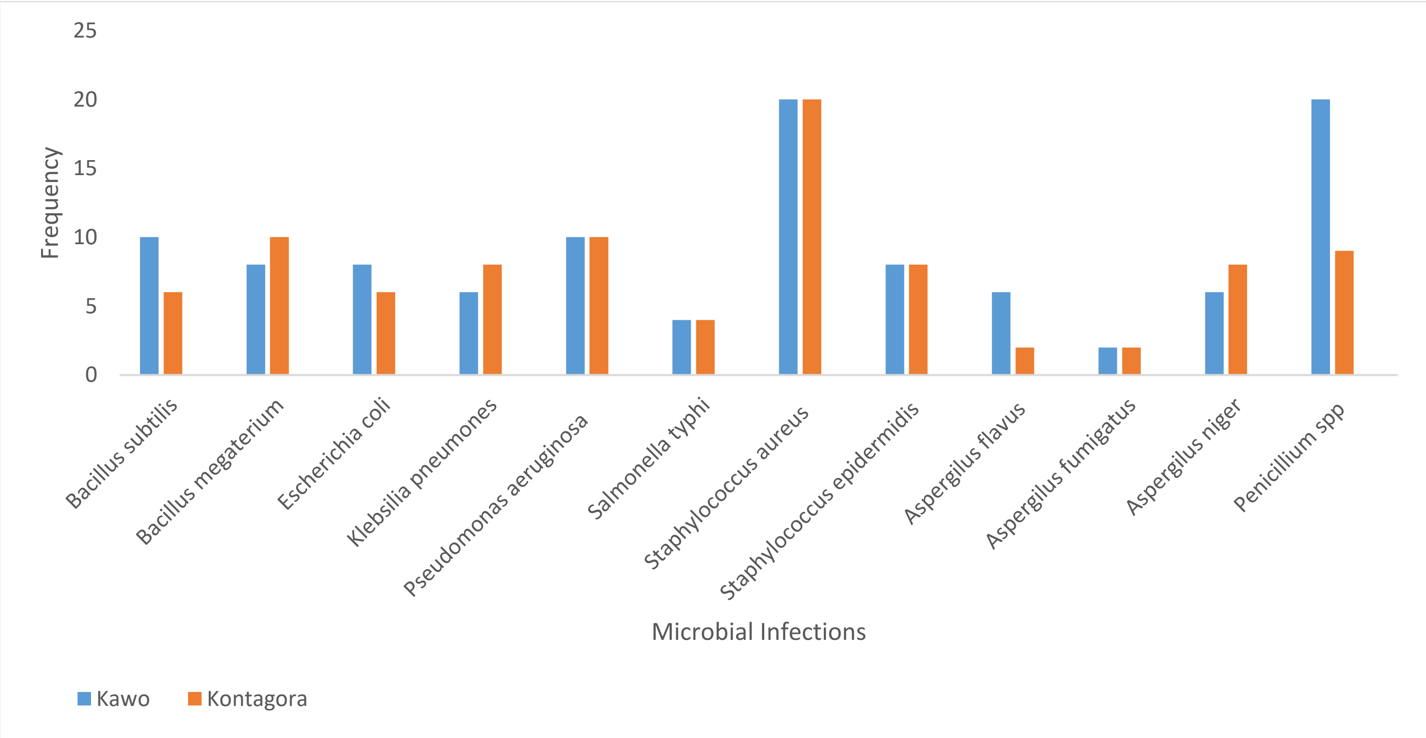

Figure 1: Average Intensity of Pathogens in Meats Sampled at Kawo and Kontagora.

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Table 2: Heavy Metal Analysis of Meat Samples from Kontagora Abattoir

Animal Type	Meat Parts	Heavy Metals (mg/kg)							
		Pb	**Cd**	**Zn**	**Cu**	**Cr**	**Ni**	**Fe**	**Mn**
Goat	Heart	0.09	0.06	0.18	0.006	0.05	0.03	100.26	0.84
	Liver	0.08	0.03	0.72	0.012	0.11	0.37	84.11	0.88
	Kidney	0.07	0.001	0.50	0.015	0.12	0.32	100.01	0.82
	Tripe	0.01	0.09	0.72	0.013	0.18	0.41	114.28	0.97
Sheep	Heart	0.08	0.02	0.13	0.004	0.23	0.01	100.23	0.76
	Liver	0.09	0.009	0.48	0.019	0.15	0.25	98.16	0.79
	Kidney	0.06	0.04	0.41	0.015	0.12	0.35	98.23	0.81
	Tripe	0.11	0.015	0.80	0.012	0.22	0.73	103.40	0.92
Cow	Heart	0.10	0.03	ND	0.007	0.13	0.04	107.01	ND
	Liver	0.14	0.05	0.03	0.004	0.21	0.32	96.40	ND
	Kidney	0.15	0.06	0.07	0.011	0.29	0.33	97.51	ND
	Tripe	0.19	0.08	ND	ND	0.36	0.61	120.40	ND
Permissible Limits		**0.1– 0.5**	**0.05– 1.0**	**40– 100**	**30– 40**	**< 1.0**	**0.1 – 1.0**	**0.3 – 1.0**	**0.5 – 5.0**

Permissible Limits Sources: [40, 41, 42]

Table 3: Heavy Metal Analysis of Meat Samples from Kawo Abattoir

Animal Type	Meat Parts	Heavy Metals (mg/kg)							
		Pb	**Cd**	**Zn**	**Cu**	**Cr**	**Ni**	**Fe**	**Mn**
Goat	Heart	0.20	0.20	0.19	0.008	0.08	0.03	102.43	1.02
	Liver	0.13	0.003	0.58	0.019	0.16	0.40	97.07	1.04
	Kidney	0.11	0.004	0.51	0.018	0.19	0.47	101.09	1.01
	Tripe	0.16	0.003	0.87	0.071	0.24	1.03	113.62	1.09
Sheep	Heart	0.85	0.005	0.16	0.016	0.23	0.02	102.21	0.94
	Liver	0.81	0.004	0.53	0.026	0.21	0.28	99.38	0.99
	Kidney	0.73	0.004	0.42	0.017	0.23	0.44	120.96	1.04
	Tripe	0.20	0.007	0.68	0.018	0.28	0.99	115.01	1.09
Cow	Heart	0.13	0.008	0.12	0.009	0.07	0.022	110.66	0.39
	Liver	0.25	0.021	0.49	0.009	0.23	0.51	101.28	1.70
	Kidney	0.98	0.01	0.26	0.014	0.31	0.33	104.34	1.27
	Tripe	0.20	0.03	0.64	0.005	0.44	0.94	115.62	1.63
Permissible Limits		**0.1 – 0.5**	**0.05 – 1.0**	**40 – 100**	**30 – 40**	**< 1.0**	**0.1 – 1.0**	**0.3 – 1.0**	**0.5 – 5.0**

Permissible Limits Sources: [40. 41, 42].

DISCUSSIONS

The overall microbial load was between 3.6– 4.25 x 10^{3} cfu/g for meat sampled in Kawo and 1.43 – 1.55 x 10^{3} cfu/g for Kontagora. This conforms to the satisfactory condition of microbial count in meats, safe for human consumption by standards [48]

The total viable bacterial count was higher in mutton and beef sampled in Kawo. The total coliform count (TCC) was 0.65 – 1.63 x 10^{3} cfu/g in Kawo and 2.0 – 5.75 x10^{2} cfu/g for Kontagora.This study indicates the evidence of contamination of fresh raw meat in Kawo and Kontagora in Niger state, Nigeria. These values represent a moderate level of bacterial contamination, as frequently seen in food samples or other agricultural products [13]. Reports from Odo *et al*. [14] have also pointed at meat and its products sold in some reported parts of Nigeria contaminated with various species of bacteria and fungi.

The total bacterial count of the fresh meat sampled from both markets is attributed to the abundant nutrients on meat, which enables microbial growth. The marked differences in bacterial diversity and growth between both markets is dependent on their distinct environmental conditions, hygienic practises, handling and transportation, poor environmental conditions and access to clean water and unhygienic handling of meat, which negates proper protocols were evident in the study areas. The high bacterial count reported in this study area is similar to studies on fresh beef in Kebbi State (3.2×10^5 to 3.9×10^8 cfu/g) [15] and ($2.24 \times 10^4 – 5.01 \times 10^4$cfu/g) in Calabar [16]

Twelve (12) isolates of eight (8) genera were reported from both markets, which included *Bacillus subtilis, Bacillus megaterium, Staphylococcus aureus, Staphylococcus epidermidis, Escherichia coli, Salmonella typhi, Klebsilia pneumones, Pseudomonas aeruginosa, Penicillium spp, Aspergilus fumigatus, Aspergilus flavus and Aspergilus niger* These are potentially pathogenic microorganisms constituting a direct hazard to health [49] Similar reports on these microorganisms have been previously recorded in foods and other environments [17]. However, there was no significant difference in the level of prevalence in both sites, as they both have close microbial diversity ($p < 0.05$).

This study shows a high dominance of *Staphylococcus aureus* in all meats sampled from both markets (18.51 %), which was also the case of fresh beef sold in Kebbi State, Nigeria (16.3 %) [15] but quite lower (37.95 %) in goat meat sold in markets as reported from Dhaka city of Bangladesh [18]. However, this differ from reports in Calabar, Nigeria where it was not found in their study [16]. *Staphylococcus aureus* and *Staphylococcus. epidermidis* were also isolated previously in beef burger in Egypt with incidence rate at 40 % and 23.33 % respectively [19]. Contamination of meat with *Staphylococcus aureus* may be during direct contact with limbs while sneezing or coughing during any form of respiratory infections and consumption could result to food poisoning, characterized with nausea, vomiting, abdominal cramps and sometimes diarrhoea.

Staphylococcus epidermidis was present in all sampled meat except beef from Kontagora. It is an opportunistic pathogen, which contaminates raw meat through handling during processing and packaging. Reports show that certain strains possess staphylococcal enterotoxin genes (such as SEC epi), which show high rates of antibiotic resistance, which can serve as reservoir for spreading resistance genes [20]. Although, it is less virulent than Staphylococcus aureus, their presence signifies an emerging public health concern.

Staphylococcus aureus, Staphylococcus epidermidis, Escherichia coli and Klebsilia pneumones were also isolated and identified in raw goat meat at retail markets in India [21]. In Malawi, Staphylococcus aureus, Staphylococcus epidermidis, Escherichia coli and Klebsilia pneumones were also isolated and identified in raw goat meat examined by [22]. The presence of *Escherichia coli* in fresh meat samples in Kawo (7.41 %) and Kontagora (5.6 %) markets, is an indicator of faecal contamination from poor sanitary state of the environment during slaughtering and processing, unhygienic handling practices and exposure on the retail tables. As stated by [15], presence of enteric bacteria in meat is attributed to faecal contamination, which could result to food-borne outbreak.

It has been asserted that *Salmonella spp* is a common contaminant of meat and poultry [23], which was also evident in this study. The isolation of *Salmonella typhi*, though less predominant (3.7 %) in both study sites may be a result of exposure and handling at retail tables. This poses a serious health hazard. It was reported, though higher in Benue state (19.2 %) [24] and 15.3 % in Katsina State, Nigeria [25]. It is a bacterial pathogen that causes typhoid fever, a major public health concern in developing countries especially Nigeria [26]. Incidence rate of salmonella accounts to about 200m to over 1 billion infections globally, with 161,000 deaths linked to food-borne-illnesses [27]. This illness is attributed to poor environmental sanitation and access to portable water, via contamination of consumables with urine or faeces from infected persons, as it has great ability to survive outside of the animals' stomach.

The incidence of *Klebsilia pneumones* in Kawo is 5.6 % and 7.41 % in Kontagora, which is in line with 16.7 % isolated in fresh meat sold in Calabar, Nigeria [16] as it indicates that the techniques of slaughtering exposes tools and skin to these gut bacteria.

Pseudomonas aeruginosa, an identified isolate in this study (9.26 %), is a nosocomial pathogen, responsible for change in colour, odour and taste, which is evident to meat spoilage. Pseudomonas spp has been found in various surfaces including humans, who serve as hosts [28]. [29] discovered Pseudomonas aeruginosa as one of the most predominant species of concern in a beef fabrication facility in the United States.

The presence of Bacillus subtilis (9.26 %) in Kawo and 5.6 % in Kontagora is close to 7.8% reported in Egypt [30], which is most likely due to the heat resistance of the spores, which enable them to persist in most environment. This infection is characterized by nausea, vomiting and abdominal cramping. Bacillus megaterium is known to be abundant in soils, which makes it commercialized for its metabolites, for agricultural applications through inoculation.

The total fungal counts ranged from 0.5 – 5.0 x 10^2 cfu/g in Kawo and 0.5 - 3.1 x 10^2 cfu/g in Kontagora, with the presence of Penillium spp, Aspergilus fumigatus, Aspergilus flavus and Aspergilus niger (Figure 2). This is in line with the FAO/WHO standard limit (log 10^2 cfu/g) for safe consumption [49]. [31] recorded 0.43 – 5.40 x 10^3 cfu/g in offal of camels and goats respectively, who also opines that the gradual increase in fungal counts as the time progresses may be as a result of surface contaminants or due to gradual loss in water activity in the meat, which makes it more conducive for fungal growth

Aspergilus spp are known to do well at temperature as high as 45 ^{0}C but only a few below 10 ^{0}C, allowing to colonize wide range of environment including stored food products. It is airborne, making dispersal through inhalation for man and contamination at different levels of the food chain. It can cause hypersensitive reactions, chronic pulmonary and other life-threatening invasive infections in immune-compromised individuals Isolates of Aspergilus fumigatus (1.85 %) in this study agrees with the presence of azole-resistant Aspergilus spp in raw materials used in sampled bakeries in Portugal [32]. [33] asserted the possibility of putting at risk the health of consumers of chicken nuggets in Brazil and sampled raw cow milk in Argentina [34]. However, there is possibility of contamination from Agricultural and other food products from the markets in this study. WHO, [35] categorised it as a critical fungal pathogen that can cause invasive acute and sub-acute systemic fungal infections for which drug resistance or other treatment and management challenges exist.

Aspergilus niger is a common, black xerophillic fungus, that acts as a progressive spoilage organism, affecting the quality of stored meat. It thrives in humid conditions, posing risks of mycotoxin production. Aspergilus flavus are known to produce aflatoxins, which are classified as carcinogenic and genotoxic compounds, which have been reported in meat products sampled in meat processing facilities and markets [36, 37].

Penicillium spp is a major fungus that thrives on raw food materials as it has the ability to survive under tropical climates and varying humidity level [38]. It is an opportunistic pathogen in immune-compromised individuals, of which WHO has termed it with other three fungi as pathogenic Fungi for Research, Development and Public Health action [35]. It is a common spoilage fungi and potential toxigenic contaminant of raw meat and meat products during processing and storage. Some produce mycotoxins, which are toxic products of certain microscopic fungi, and could become potential contaminants at all levels of the food value chain. Aspergilus and Penicillium spp were reported to produce Ochratoxin A (OTA), which is a highly toxic and stable mycotoxin linked to liver and kidney damage (nephrotoxicity), possible birth defects and pose significant health risks to humans and animals [39]. The high level of contamination in this study may cause various health concerns.

Lead (Pb) concentrations from the Tables 2 and 3 ranged from 0.01 mg/kg in goat kidney from Kontagora to 0.98 mg/kg in cow kidney from Kawo. Meat samples from Kontagora generally showed lower Pb levels than the 0.1 – 0.5 mg/kg recommended values set by the European Food Safety Authority [41], which were lower than Pb in the heart, liver and kidney (0.73 – 0.85 mg/kg) of sheep and the kidney of cow (0.98 mg/kg) from Kawo. Concentrations of Pb in all meat samples from Kontagora were lower than those from Kawo. These results disagree with 0.01 – 0.02 mg/kg Pb reported by [43], as being highest in liver of cattle than goat meat parts examined. Pb value of 0.08 – 0.81 mg/kg in both livers and hearts respectively and 0.06 – 0.98 mg/kg in kidney of animals from this study is higher than 0.01 – 0.02 mg/kg reported of livers and hearts and 0.02 – 0.03 mg/kg of kidney by [43]. This disparity may be due to difference in handling, feeding and processing patterns of the animals.

From the Tables 2 and 3, cadmium (Cd) levels ranged from 0.001 mg/kg in goat kidney to 0.09 mg/kg in the same goat tripe from Kontagora. This implied that meat samples from Kawo abattoir have less Cd content. Meat samples from both sites revealed lower Cd levels than the 0.05 – 1.0 mg/kg recommended limits set by [41]. Cd levels in all the meat parts of sheep and cow from Kontagora were higher than those obtainable from Kawo. However, there was irregular variations in the levels of Cd in the hearts, liver, kidney and tripe of goat meats from the two locations. Cd levels in the livers (0.003 – 0.009 mg/kg), hearts (0.005 – 0.2 mg/kg) and kidneys (0.001 – 0.06 mg/kg) of animals in this study is lower for livers than 0.00 – 0.02 mg/kg, intermediate 0.00 – 0.02 mg/kg and 0.01 – 0.02 mg/kg for heart and kidney respectively of animals reported by [43].

Zinc (Zn) levels from Tables 2 and 3 ranged from 0.00 mg/kg in cow heart from Kontagora to 0.87 mg/kg in goat tripe from Kawo. Except for Zn in goat liver, its content in other meat parts is lower in Kontagora than Kawo. The same observation was recorded for the cow parts (0.00 – 0.07 mg/kg from Kontagora being lower than 0.12 – 0.64 mg/kg from Kawo. However, Zn in sheep tripe from Kontagora recorded a higher value (0.80 mg/kg) than 0.68 mg/kg of Kawo. Generally, meat parts of the understudied animals from Kawo abattoir showed a lower Zn content than those obtained from Kontagora abattoir. These values, however are lower than the 40 – 100 mg/kg FAO/WHO [40] standard recommended limits. These results are lower than 1.72 – 3.54 mg/kg, 3.24 – 3.29 mg/kg and 2.34 – 2.96 mg/kg Zn in livers, hearts and kidneys respectively of animals reported by [43]. Concentration of 71.50 mg/kg Zn observed by [8] in goat heart from Ayegbaju-Ekiti, Nigeria was much higher than the value observed in this study for goat parts.

Levels of copper (Cu) in Table 2 representing meats from Kontagora ranged 0.00 – 0.019 mg/kg from cow tripe to sheep liver. These values are lower than 0.005 – 0.019 mg/kg from cow tripe to goat liver as in Table 3 representing meat samples from Kawo. The livers of sheep from Kontagora and goat from Kawo recorded the same values 0.019 mg/kg of Cu. These concentrations are generally much lower than the permissible limits of 30 – 40 mg/kg recommended by NAFDAC [42] for meat. [9] reported almost similar values ranging from 0.011 – 0.013 mg/kg for liver and kidney of cattle sold in Owerri Metropolis, Nigeria. The values of beef from this study, are however lower than 1.45 ppm Cu levels reported by [44] in Soroti beef in Uganda and as well, lower than 2.00 – 186.5 µg/g reported by [2] in Kaduna, Nigeria.

From Table 2, chromium (Cr) concentrations ranged from 0.05 mg/kg in goat heart to 0.36 mg/kg in cow tripe from Kontagora abattoir. These values are lower than 0.07 – 0.44 mg/kg from cow heart to cow tripe from Kawo as represented in Table 3. The cow tripe from the two sampling locations harbor highest levels of Cr among the meat parts. FAO/WHO [40] Cr recommended limits of < 1.0 mg/kg are higher than these concentrations. The values of Cr in this study are lower than 15.80 µg/g and 17.48 µg/g reported in cattle tripe and liver respectively by [2]. [44] reported a higher Cr value 19.37 ppm than obtained for cow meat parts in this research. [45] reported 0.00 – 0.66 mg/kg, 0.18 - 0.57 mg/kg and 0.00 – 0.66 mg/kg Cr in cow liver, kidney and tripe respectively. These results are close to the values of Cr obtained in the animal parts from Kawo.

Nickel (Ni) levels in Table 2 representing meats from Kontagora ranged 0.01 – 0.73 mg/kg from sheep heart to its tripe. These values are lower than 0.02 – 1.03 mg/kg from cow and sheep hearts to goat tripe as in Table 3 representing meat samples from Kawo. The hearts of cow and sheep from Kawo recorded almost close values 0.02 and 0.022 mg/kg respectively of Ni. The concentrations of meat samples in this present study are lower than the permissible limits of 0.1 – 1.0 mg/kg recommended by FAO/WHO [40], except in the tripe of Kawo goat that recorded higher value 1.03 mg/kg than the standard permissible limit, hence unsafe for consumption. Also, sheep and cow tripes may not be safe for consumption due to Ni values 0.99 mg/kg, almost equal the upper permissible limit of 1.0 mg/kg for Ni. [46] reported higher Ni content (9.8 – 22.1 mg/kg) in the meat samples studied than the values obtained in this work. [2] reported higher value 1.67 µg/g for cow tripe and relatively close value 0.65 µg/g for liver compared to the results from this study.

From Table 2, levels of iron (Fe) ranged from 84.11 – 120.4 mg/kg. Table 3 shows Fe range from 97.07 – 120.96 mg/kg, revealing higher Fe content in the meat parts collected from Kawo than those from Kontagora, except in goat and cow tripe recording 114.28 > 113.62 mg/kg and 120.40 > 115.62 mg/kg respectively. These values appear high but may not pose any threat to human health, since there has not been any specific limit recommended for Fe in meat. Recommended daily intake (RDI) of Fe varies with regards to age and sex. 8

mg/day and 18 mg/day are recommended for adult men and women within age 19-50 years respectively. However, the tolerable upper intake level for Fe is 45 mg/day for adults [47]. Fe values recorded in this study are lower than 241.47 and 632.6 µg /g reported by [2] for cow liver and tripe respectively. In the same vein, [44] reported a higher Fe value 164.33 ppm than obtained for cow meat parts in this research. [45] cited higher mean values of Fe than that obtained in this study. For Fe content in goat and cow, [45] reported 436.33 and 112.4 mg/kg; 208.56 and 148.11 mg/kg; 208.56 and 303.60 mg/kg in livers, kidneys and tripes respectively.

Manganese (Mn) levels in Table 2 showing meat parts from Kontagora abattoir are generally lower (0.00 – 0.97 mg/kg), irrespective of the meat parts, than are obtained in meat parts from Kawo abattoir (0.39 – 1.70 mg/kg) shown in Table 3. Mn levels in this study are lower than the upper limit 5.0 mg/kg recommended by the FAO/WHO [40] for food. Mn results obtained in this study for cow liver and kidney are higher than those reported of cattle liver and kidney as 0.020 mg/kg and 0.015 mg/kg respectively [9]. [45] reported mean Mn concentrations of 1.72 mg/kg in cow liver. This value is close to 1.70 mg/kg Mn in cow liver from Kawo in this study, but higher values 2.33 mg/kg, 4.63 mg/kg and 3.58 mg/kg were reported for cow kidney, and goat liver and kidney respectively than recorded (0.00 – 1.70 mg/kg range) in this study for all the examined meat parts.

CONCLUSION AND RECOMMENDATIONS

This study reveals microbial contamination of meat and heavy metals presence. All samples had viable microbial loads within the borderline of standard limit and heavy metals in quantities below the recommended allowable limits set by standard organisations, which implies that the meats are safe for consumption. However, operational practices, which involves sanitary level of the abattoirs, environmental and hygienic conditions, handling by the retailers should be regularly upheld and monitored to reduce predisposing the meats to contamination, growth of microbes and spoilage, resulting to poor quality and unsafe consumption.

The following recommendations are advanced to improve on the current research:

1. Meat handlers should be educated and encouraged to engage in good behavioural practices, strict hygienic measures, proper waste disposal system, improved processing and handling techniques, transportation and storage conditions. These will minimise the risk of contamination and pathogenic infection.
2. Regulatory efforts and continuous inspection of animals before slaughter by relevant authorities, provision of good water supply and use of sterile equipment must be practised to improve meat quality and safety.
3. There should be need for continuous health risk assessments of microbes and heavy metals.
4. Pollution indices should be carried out to check the level of pollution by these heavy metals on the environment.
5. Consumers should practice thorough cooking of meat before consumption to reduce the risk of food-borne illnesses.

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Aim: This study focuses on the isolation, identification, assessment of microorganisms and evaluation of heavy metal levels/concentrations in the meat samples. Determining the types of micro-organisms present, their counts and the levels of heavy metals present in the meat parts of these animals, makes it necessary for promoting safer meat consumption in this region.

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