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Original Research Article

A comparative study of bacteriological load of freshly fried and stored *sallah* meat from Danbatta Local Government Area of Kano State, Nigeria

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A comparative study of microbial loads of offal and muscles of freshly fried and stored meats prepared from ram, bull, goat and camel slaughtered during the Sallah festival in Danbatta Local Government Area of Kano State was carried out. The objective was to ascertain the microbial safety of the meat products as consumed by the people in that area. A total of seventy two samples were collected randomly from different households that slaughtered and fried any of the four animal species which comprised of offal and muscles. Parts of the meat were analyzed immediately as freshly fried samples while the other parts were stored for a period of four weeks at ambient temperatures (29±5°C) as it is the common practice of the people in that community. Microbial assay was carried out at two weeks interval to determine the possible presence of such pathogens as *Staphylococcus aureus, Staphylococcus eipidermidis, Klebsiella spp and E. coli*. An analysis of variance (ANOVA) was used to compare between the microbial loads in the samples of the muscles and offal. Results revealed the presence of all the pathogens in all the samples examined. The highest in the frequency of occurrence among all the samples was *Staphylococcus aureus*. The least bacterial count (0.67 x 10^3) expressed as colony forming unit (cfu) per gram of meat was recorded in the camel muscles whereas as the highest count (7.9 x 10^3) was recorded in the offal of rams. Although the microbial counts were below the safety levels recommended by the Center for Food Safety for ready-to-eat meats, the study concludes that the high frequency in occurrence of *Staphylococcus aureus* is a serious public health concern.

Key word: Danbatta, *Sallah* meat, bacteria, camel, fried meat.

INTRODUCTION

Meat is defined as 'the edible part of the skeletal muscle of an animal that is healthy at the time of slaughter (Olaoye, 2011). Meat is composed chemically of four major components including water, protein, lipid, carbohydrate and many other minor components such as vitamins, enzymes, pigments and flavour compounds (Calkins et al., 2007; Biesalski and Nohr, 2009; Olaoye, 2011). The relative proportions of all these constituents give meat its particular structure, texture, flavour, colour and nutritive value. However, because of its unique biological and chemical nature, meat undergoes progressive deterioration from the time of slaughter until consumption (Jay et al., 2005; Adam

and Moss, 2007; Norrung et al*.,* 2009; Adeyeye , 2016).

The term *Sallah* meat is popularly known as *Naman Sallah* in Hausa land. It is a meat from sacrifice made during *Sallah* period, which is a period in Islam that falls in Islamic month of *Zul-hijjah* (the twelfth month in Islamic Calendar). The animals that are slaughtered for the sacrifice must be at least 1 year old and of different Halal (i.e., not prohibited for consumption) species and this includes cows, bulls, rams, goats sheep, and camels; and must be free from the 4Ds (diseased, downed, disabled, or dead). The sacrifice must be performed by the capable individuals using any of these animals, and must be carried out within the stipulated dates, that is, the 10th to 12th day of the month of *Zul-hijjah.*

In many developing countries such as Nigeria, meat is widely consumed as a source of protein; it is either eaten cooked or processed into other forms to avoid any form of spoilage (Thippareddi and Sanchez, 2006, Heinz and Hautzinger, 2007; Yusuf et al.,2019; Igwegbe et al.,2019a). The rapid expansion in meat processing plants in different parts of the world is due to continuous increase in demand for safe meat products with low cost and high in nutritive value (Umoh, 2004; Tijjani and Jumare, 2014; Shaltout et al., 2014).

Globally, the consumption of meat is determined by many factors including culture, religion and affordability; and the traditionally processed meat products are consumed in different countries (Vilar et al., 2000; Yusuf et al.,2019; Igwegbe et al.,2019a). The major primary unit of meat is called carcass. It represents the ideal meat after the blood, head, hide, intestine and shackles have been removed. The edible parts of a slaughtered meat animal include muscles, fat and glands or organs such as heart, liver, kidney tongue and brain. Age and sex of the animals have a major influence on the quality of meat that is produced from animals (Monson et al*.,* 2005; Rao et al., 2009). Most meat have high water content corresponding to the water activity of approximately 0.99 which is suitable for microbial growth and toxin production (Leake, 2006; Rao et al., 2009; Zukal and Incze, 2010; Roos et al., 2018).

Food borne diseases are diseases resulting from ingestion of bacteria, toxins and cells produced by microorganisms present in food (Jay et al*.,* 2005; Reiman and Cliver, 2006; Adam and Moss, 2007; 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 toxins (Reiman and Cliver, 2006; Clarence et al., 2009). It is a major cause of illness and death worldwide (Adak et al., 2005; Reiman and Cliver, 2006). Recognizing this, the World Health Organization (WHO) developed its Global Strategy for Food Safety (Kaferstein, 2003; Adak et al., 2005). It has been reported that, in the developing world, food borne infection is the leading cause of the death of many children. The resulting diarrheal disease has also been reported to have long-term effects on children's growth as well as on their physical and cognitive development (Adak et al., 2005; WHO/UNICEF, 2009). In the industrialized nations, food borne infection causes considerable illness, heavily affecting healthcare systems (Adak et al., 2005; Reiman and Cliver, 2006)..

Microorganisms that occur in meat and meat products most times are responsible for foodborne illnesses. These micro-organisms include *Bacillus spp, Clostridium spp, Escherichia coli, Salmonella spp, Shigella spp, Staphylococcus aureus, Streptococcus pyogenes, Proteus, Pseudomonas, Leuconostoc, Lactobacillus spp, Micrococcus, Mycobacterium spp, Vibrio spp* and others (Norrung et al*.,* 2009 Jay et al*.,* 2005; Reiman and Cliver, 2006; Adam and Moss, 2007). These organisms may be transferred from the animals or their handlers at first, and then from the raw meat to cooked meat by the meat handlers, surfaces or utensils that come in contact with the meat (Yusuf et al., 2012; Igwegbe, et al*.,* 2019b). There exist different types of meat product ranging from the industrially processed corned beef, ham, bacon sausage to the indigenous or traditionally processed ready-to-eat meat products such as *balangu* (roasted meat), "*kilishi*, *dan-bu-nama*, *tsire*, *jirga*, *ndako*, *banda*, *suya, kamsa* and many more, that are consumed in Nigeria (Yusuf et al., 2012; Yusuf et al*.,* 2019; Abdullahi et al*.,* 2019).

According to WHO statistics, foodborne diseases is the second leading cause of mortality in low-income countries, including Nigeria, and kills more people than human immunodeficiency virus infection / acquired immunodeficiency syndrome (HIV/AIDS), malaria, or tuberculosis. The practice of storing the *Sallah* meat for an extended period is very common among the inhabitants of Danbatta LGA in Kano State, Nigeria. The meat is usually deep-fried at large quantities on the *Sallah* day, allowed to stay at room temperatures until consumed without re-warming. There is limited information on the possible effects of this practice on the bacteriological load of the stored meat and the health consequences. This study is therefore designed to investigate the total counts and types of microorganisms that may be present in the meat products during the extend period of the storage at room temperatures.

MATERIALS AND METHODS

Sample collection

This study was conducted in Danbatta Local Government Area in Kano. Samples (200g each) of fresh fried Sallah meats were collected directly from randomly selected households in the area at the evenings of the 10th to 12th of the Sacrificial Month of Zul-Hijjah, in previously sterilized containers. The samples were transported to the laboratories for the microbial assessments. Only the edible parts (muscles and offal) from the slaughtered (scarified) animals: rams, bulls, goats and camels, were used in the assessments. A total of 72 samples were collected from six different households for each type of the animals and the analyses were conducted in triplicates. The analyses were carried out at two weeks interval, starting from the day the meats were fried to four weeks after the frying, which is the

maximum period the fried Sallah meat is usually stored by the locals, at ambient (room) temperatures (29±5°C).

Sample Preparation

The meat samples were thoroughly ground using previously sterilized pestle and mortar, 11g were transferred into 99ml of sterile peptone water, and then shaken thoroughly to make a homogenous mixture (these served as stock solutions for each sample). Serial dilutions were made using 1 ml from the stock homogenate and 9 ml of the sterile distilled water. Several dilutions were made, up to 5 folds (i.e.,10^5) for each sample, in order to obtain discrete colonies as described by Banwart (2012).

Media Preparation

Nutrient Agar (NA) for total aerobic plate count, Mannitol salt agar (MSA) for *Staphylococcus*, and desoxycholate citrate agar (DCA) for *Salmonella*/*Shigella* were prepared according to the manufacturer's instructions, and used in this study for the enumeration of bacteria, as well as for pure culture selection of the microorganisms. All glassware used in the analysis were sterilized in a hot oven at 170 ± 5°C for at least two hours, while the media and distilled water were sterilized by autoclaving at 121°C for 15 min at 15 psi (Abdullahi et al., 2019; Igwegbe et al., 2019a). Plating was carried out in triplicate and pour plate method was used to make the viable counts (Quinn et al., 2002; Jay et al., 2005; Vipul et al., 2012; Igwegbe et al., 2019b). In this method, one (1) ml of the inoculums was mixed thoroughly in molten plate count agar held in a hot water bath at 47 ± 2°C. The agar was allowed to set; the plates were inverted and then incubated at 32°C for 24 – 48 hours for bacterial counts (including mesophilic and thermophilic spore formers) and at 25°C (Cheesbrough 2006). For each dilution, the viable colonies, which appeared colorless, in the three plates were counted and the means were calculated.

Isolation of the Microorganisms

The isolation of Escherichia coli was achieved following the methods described by Jay et al. (2005) and Abdullahi et al. (2019); that of *Staphylococcus aureus* and *Staphylococcus epidermidis* were isolated by the methods described by Stanley et al. (2015) while *Pseudomonas aeruginosa* and *Klebsiella* spp. were isolated by the methods described by MacFaddin (2000). The isolated organisms were further subjected to Gram-staining techniques as described by Cheesbrough (2006).

Microscopic Examination and Identification of Colonies

The characterization and identification of the colony isolates were achieved by morphological examination of the colonies in the plates for their appearance, size, elevation, form, edge, color and odor and the observations were properly noted. The biochemical tests including oxidase, urease, catalase and coagulase reactions, citrate utilization, Voges-Proskauer, motility, sugar fermentation, methyl red and indole production tests were also carried out as described by Cheesbrough (2006).

Statistical Analysis

This study was designed as a complete randomized design (CRD) and the results obtained were subjected to a one way analysis of variance (ANOVA). The test for significance among means was carried out using the Tukeys's Honest Significant Difference (HSD) Test at 5% level of significance (Dean et al., 2017).

RESULTS AND DISCUSSIONS

It is generally recognized that illnesses due to the consumption of contaminated foods are perhaps the most widespread health problems in the contemporary world today and an important cause of reduced economic productivity. Recent studies examining the morbidity and mortality of foodborne diseases have confirmed the significant public health burden posed by these diseases. In developed countries, it is estimated that one-quarter to one-third of the population are made ill each year because of foodborne diseases. In the developing countries, including Nigeria, the burden is much more severe; and therefore there is need to regularly survey the food preparation, handling and storage techniques to ensure the safety of the food in on hand, and the health of the consumers on the other hand. In the present study, the results of the microbial assessments of different types of the Sallah meat as consumed in Danbatta Local Government Area of Kano State, Nigeria, are tabulated and discussed. The total bacterial counts, expressed in colony-forming unit (cfu x 10^3) per gram of different parts of the *Sallah* meat, recorded in this study are presented in Table 1, with their standard deviations. No significant differences ($P \geq 0.05$) were observed between the microbial contents of the meat parts (muscles and offal) throughout the storage periods. The highest bacterial count was recorded from the bull's muscles at the beginning of the storage period; and the least was recorded from the camel's muscles during the same period (**Table 1**). Similarly, the highest and lowest bacterial counts recorded from the offal were from rams and camels, respectively, at the beginning of the storage period (Table 1). This may be an indication that the meat were properly deep-fried and protected from further contamination after frying. On the other hand, it was observed that the microbial numbers decreased gradually as the storage period progressed from zero to the fourth weeks, in both the muscles and the offal.

The highest number of bacteria was recorded in camels' muscles during the fourth week of the storage period, and the lowest was recorded from the muscle of ram at the same period. In general, the lowest and highest bacterial

Table 1. Mean Bacteria Counts (cfu/g x10^3) Recorded in Muscles and Offal of Ram, Bull, Goat and Camel During the Four Week of Storage of Sallah Meats at Ambient Temperatures[1]

	Storage Period (Weeks)[2]		
Species / Part	**0**	**2**	**4**
Ram			
Muscle	5.70 ±2.44[a]	5.37±4.19[a]	3.17±0.67[b]
Offal	7.20±0.20[a]	7.90±0.52[b]	3.20±1.11[c]
Bull			
Muscle	6.37±1.58[a]	3.91±4.15[b]	3.47±0.27[b]
Offal	6.27±2.91[a]	2.74±2.48[b]	4.87±0.67[c]
Goat			
Muscle	5.63±2.48[a]	5.03±2.48[b]	4.33±0.21[c]
Offal	5.33±2.60[a]	4.07±4.55[b]	4.37±0.86[b]
Camel			
Muscle	4.57±0.84[a]	4.39±1.99[a]	6.10±0.87[b]
Offal	4.63±1.60[a]	3.95±4.89[b]	4.60±0.70[b]

[1]Values are means of triplicate determinations ± Standard Deviations;
[2]In any row, means bearing similar superscripts are not significantly different (P≥0.05);

counts recorded from the second and fourth weeks of the storage periods were obtained from the offal and muscles of bull and camels, respectively (Table 1). Moreover, the total bacterial counts recorded from the different fried *Sallah* meats during the four weeks period of storage did not exceed the limits for ready-to-eat foods of 10^2 to < 10^4 cfu/g prescribed by the Food Standards (2002), and Centre for Food Safety (2007). The low microbial load recorded in this study is in agreement with the observations by Nester et al. (2001) and Adam and Moss (2007), who attributed their observations to the low water activity (a_w) values of dehydrated foods which are usually below 0.6. This, the authors further observed, is the limiting value for the active growth of any microorganism (even though survival of spores may still occur). It is also important to note that, at low a_w, the spoilage of foods is not microbiological, but due to insect damage or chemical reactions such as oxidation (Leake, 2006; Zukal and Incze, 2010; Roos et al., 2018). In this study, however, higher bacterial counts were observed particularly in the offal, during the first and second weeks of the storage period; which decreased as the storage period progressed, up to the end of the fourth week (Table 1). This increase could be due to some contaminants on the products at the beginning of the experiments. Furthermore, the presence of moisture is directly related to water activity and the higher the water content, the more susceptible the food will be to microbial spoilage and unfavourable chemical reactions (Shafiur Rahman and Perera, 2007; Zukal and Incze, 2010). Moreover, no significant changes

(P≥ 0.05) were observed in the mean microbial counts of the of the fried meat parts from the second up to the fourth weeks of the storage period (Table 2). This may possibly be as a result of the fact that the moisture content might have stabilized as the storage period progressed. It is important to mention here that the water activity of the fried meat was not evaluated because the purpose of this study was to simulate the conditions (ambient room temperatures) at which the *Sallah* deep-fried meats are usually kept in the community without packaging, until consumed. The result has shown that the frying process, which also helps in lowering the water activity in the product, was effective enough to prevent or minimize the activity of microorganisms throughout the storage periods.

Results of Isolation and Identification of the Bacterial Contents of the Sallah Meat

The traditional method of examining microbiological safety, storage stability, and sanitary quality of foods is to test representative samples of the final product for the presence of pathogens or spoilage organisms (Igwegbe et al,. (2019b). Different microbial groups (e.g., aerobic plate counts and yeast and moulds); indicator bacteria such as Coliforms are used as an indicator of sanitation per gram or milliliter of a product (Jay et al., 2007; Olaoye et al., 2010). The results of the bacterial isolations and identifications obtained during the four weeks storage of the *Sallah* meat in the course of this study are presented in Tables 2, 3, 4**,** and **5**, for both the muscles and offal. The isolated and identified bacteria included *Staphylococcus aureus, Staphylococcus eipidermidis, Klebsiella spp, E. coli, and Pseudomonas sp.,* and their elaborate morphological and biochemical properties were used in the process, and their details are well presented in the Tables. On the other hand, the frequencies of the occurrences of these bacteria, expressed in percentages of the number of samples in which the organisms were recorded, are presented in Tables 6, 7, 8 and 9; also with their interpretations.

The occurrence of such bacteria as *Staphylococcus aureus and E. coli* in the meat samples investigated in this study should be of public health concerns; due to the facts that they have been implicated in various diseases of man (Gilbert and Harrison, 2001; Reiman and Cliver 2006; Ogbonna et al., 2012; Falegan et al., 2017). The results for percentage occurrences of the bacteria identified in this study show that *Staphylococcus aureus* recorded the highest frequency in both the muscles and offal of the slaughtered animals (Tables 6 to 9). Gilbert and Harrison (2001) made

Table 2. Morphological and Biochemical Characterization of Bacteria Isolated in Muscles and offal of the Freshly Fried and Stored *Sallah* Meats from Ram[1]

Type of Meat	Colonial Morphology / Media*	Gram Reaction	Microscopic Appearance	Ox	Ca	Co	In	Mo	Ci	Me	Acid Production	VP	Suspected Organism
Muscles	Opaque cream yellow growth on MSA	+	Cocci in clusters	-	+	+	-	+	-	+	-	+	*Staph. aureus*
	Pinkish growth on MSA	+	Cocci in clusters	+	+	-	-	-	-	-	-	-	*Staph. eipidermidis*
	Shiny mucoid / viscous colonies on MAC	-	Short Rods	-	+	-	+	+	-	+	+	-	*Klebsiella spp*
	Green metallic sheen on EMBA	-	Short Rods in single	+	-	+	+	-	+	-	-	+	*E. coli*
	Greenish grey colonies with convex elevation and irregular edges on CLED	-	Rod in single and some in pairs	+	+	-	-	+	+	-	-	+	*Pseudomonas sp*
Offal	Green metallic sheen on EMBA	-	Short Rods in single	+	-	+	+	-	+	-	-	+	*E. coli*
	Shiny mucoid / viscous colonies on MAC	-	Short Rods	-	+	-	+	+	-	+	+	-	*Klebsiella spp*
	Greenish grey colonies with convex elevation and irregular edges on CLED	-	Rod in single and some in pairs	+	+	-	-	+	+	-	-	+	*Pseudomonas sp*
	Opaque cream yellow growth on MSA	+	Cocci in clusters	-	+	+	-	+	-	+	-	+	*Staph. aureus*
	Pinkish growth on MSA	+	Cocci in clusters	+	+	-	-	-	-	-	-	-	*Staph. eipidermidis*

[1](+) = Positive, (-) = No Reaction, Ox = Oxidase, Ca= Catalase, Co = Coagulase, In = Indole, Ci = Citrate, Me = methyl red, VP = Prosvoskeur.
*MSA = Manitol Salt Agar; MAC = MacConkey Agar; EMBA = Eosine Methylene Blue Agar; CLED = Cystine Lactose Electrolyte Deficient

Table 3. Morphological and Biochemical Characterization of Bacteria Isolated in Muscles and offal of the Freshly Fried and Stored *Sallah* Meats from Bull[1]

Type of Meat	Colonial Morphology / Media*	Gram Reaction	Microscopic Appearance	Ox	Ca	Co	In	Mo	Ci	Me	Acid Production	VP	Suspected Organism
Muscles	Opaque cream yellow growth on MSA	+	Cocci in clusters	-	+	+	-	+	-	+	-	+	*Staph. aureus*
	Pinkish growth on MSA	+	Cocci in clusters	+	+	-	-	-	-	-	-	-	*Staph. eipidermidis*
	Shiny mucoid / viscous colonies on MAC	-	Short Rods	-	+	-	+	+	-	+	+	-	*Klebsiellaspp*
	Green metallic sheen on EMBA	-	Short Rods in single	+	-	+	+	-	+	-	-	+	*E. coli*
	Greenish grey colonies with convex elevation and irregular edges on CLED	-	Rod in single and some in pairs	+	+	-	-	+	+	-	-	+	*Pseudomonas sp*
Offal	Green metallic sheen on EMBA	-	Short Rods in single	+	-	+	+	-	+	-	-	+	*E. coli*
	Shiny mucoid / viscous colonies on MAC	-	Short Rods	-	+	-	+	+	-	+	+	-	*Klebsiellaspp*
	Greenish grey colonies with convex elevation and irregular edges on CLED	-	Rod in single and some in pairs	+	+	-	-	+	+	-	-	+	*Pseudomonas sp*
	Opaque cream yellow growth on MSA	+	Cocci in clusters	-	+	+	-	+	-	+	-	+	*Staphy. aureus*
	Pinkish growth on MSA	+	Cocci in clusters	+	+	-	-	-	-	-	-	-	*Staph. eipidermidis*

[1](+) = Positive, (-) = No Reaction, Ox = Oxidase, Ca= Catalase, Co = Coagulase, In = Indole, Ci = Citrate, Me = methyl red, VP = Prosvoskeur.
*MSA = Manitol Salt Agar; MAC = MacConkey Agar; EMBA = Eosine Methylene Blue Agar; CLED = Cystine Lactose Electrolyte Deficient

a similar observation and attributed it to the salt content of the preserved meat which permits the growth of *Staphylococcus aureus.* In addition, it could be due to the fact that humans are also the primary reservoirs of *Staphylococcus aureus*. It has been reported that about 40% of healthy individuals harbor *Staphylococcus aureus* in their throats, nasal cavities, infected cuts and sores (Lawley et al. (2012). Thus, careless manual handling of raw meat by people during this festive period might have been the main cause of the higher cellular counts of *Staphylococcus aureus* in both the meats and offals.

Furthermore, temperature abuse during

Table 4. Morphological and Biochemical Characterization of Bacteria Isolated in Muscles and offal of the Freshly Fried and Stored *Sallah* Meats from Goat[1]

Type of Meat	Colonial Morphology / Media*	Gram Reaction	Microscopic Appearance	Ox	Ca	Co	In	Mo	Ci	Me	Acid Production	VP	Suspected Organism
Muscles	Pinkish growth on MSA	+	Cocci in clusters	+	+	-	-	-	-	-	-	-	*Staph. eipidermidis*
	Opaque cream yellow growth on MSA	+	Cocci in clusters	-	+	+	-	+	-	+	-	+	*Staph. aureus*
	Shiny mucoid/viscous colonies on MAC	-	Short Rods	-	+	-	+	+	-	+	+	-	*Klebsiellaspp*
	Green metallic sheen on EMBA	-	Short Rods in single	+	-	+	+	-	+	-	-	+	*E. coli*
	Greenish grey colonies with convex elevation and irregular edges on CLED	-	Rod in single and some in pairs	+	+	-	-	+	+	-	-	+	*Pseudomonas sp*
Offal	Pinkish growth on MSA	+	Cocci in clusters	+	+	-	-	-	-	-	-	-	*Staph. eipidermidis*
	Opaque cream yellow growth on MSA	+	Cocci in clusters	-	+	+	-	+	-	+	-	+	*Staph. aureus*
	Shiny mucoid/viscous colonies on MAC	-	Short Rods	-	+	-	+	+	-	+	+	-	*Klebsiella spp*
	Green metallic sheen on EMB	-	Short Rods in single	+	-	+	+	-	+	-	-	+	*E. coli*
	Greenish grey colonies with convex elevation and irregular edges on CLED	-	Rod in single and some in pairs	+	+	-	-	+	+	-	-	+	*Pseudomonas sp*

[1](+) = Positive, (-) = No Reaction, Ox = Oxidase, Ca= Catalase, Co = Coagulase, In = Indole, Ci = Citrate, Me = methyl red, VP = Prosvoskeur.
*MSA = Manitol Salt Agar; MAC = MacConkey Agar; EMBA = Eosine Methylene Blue Agar; CLED = Cystine Lactose Electrolyte Deficient

Table 5. Morphological and Biochemical Characterization of Bacteria Isolated in Muscles and offal of the Freshly Fried and Stored *Sallah* Meats from Camel[1]

Type of Meat	Colonial Morphology / Media*	Gram Reaction	Microscopic Appearance	Ox	Ca	Co	In	Mo	Ci	Me	Acid Production	VP	Suspected Organism
Muscles	Opaque cream yellow growth on MSA	+	Cocci in clusters	-	+	+	-	+	-	+	-	+	*Staphy. aureus*
	Pinkish growth on MSA	+	Cocci in clusters	+	+	-	-	-	-	-	-	-	*Staphy. eipidermidis*
	Shiny mucoid/viscous colonies on MAC	-	Short Rods	-	+	-	+	+	-	+	+	-	*Klebsiella spp*
	Green metallic sheen on EMBA	-	Short Rods in single	+	-	+	+	-	+	-	-	+	*E. coli*
	Greenish grey colonies with convex elevation and irregular edges on CLED	-	Rod in single and some in pairs	+	+	-	-	+	+	-	-	+	*Pseudomonas sp*
Offal	Opaque cream yellow growth on MSA	+	Cocci in clusters	-	+	+	-	+	-	+	-	+	*Staphylococcus aureus*
	Pinkish growth on MSA	+	Cocci in clusters	+	+	-	-	-	-	-	-	-	*Staph. eipidermidis*
	Shiny mucoid/viscous colonies on MAC	-	Short Rods	-	+	-	+	+	-	+	+	-	*Klebsiella spp*
	Green metallic sheen on EMBA	-	Short Rods in single	+	-	+	+	-	+	-	-	+	*E. coli*
	Greenish grey colonies with convex elevation and irregular edges on CLED	-	Rod in single and some in pairs	+	+	-	-	+	+	-	-	+	*Pseudomonas sp*

[1](+) = Positive, (-) = No Reaction, Ox = Oxidase, Ca= Catalase, Co = Coagulase, In = Indole, Ci = Citrate, Me = methyl red, VP = Prosvoskeur.
*MSA = Manitol Salt Agar; MAC = MacConkey Agar; EMBA = Eosine Methylene Blue Agar; CLED = Cystine Lactose Electrolyte Deficient

processing can result to high cellular counts of *Staphylococcus aureus* in the muscles and offal. Staphylococcal enterotoxins is produced by *Staphylococcus aureus*, and most food poisoning strains produce enterotoxin A (Lawley et al. (2012). Also, the presence of *E. coli* may be as consequence of careless slaughtering operations and the use of non potable water during washing of the raw meats. This is also in agreement with the findings of Umoh (2004) and Tijjani and Jumare (2014). In addition, higher frequency of *Staphylococcus aureus* recorded in this study is in conformity with the results of other researchers including those of Egbebi et al. (2016), Tijjani et al. (2015), Lawrence at al. (2016), Nwakanma et al. (2015), Annaias et al. (2017) and Faleganet al.

Table 6. Frequency of Occurrence of Bacteria Isolates in Muscles and Offal from Rams

Type of Meat	Bacteria	Frequency of occurrence (%) / Week		
		0	2	4
Muscles	*Staphylococcus aureus*	35.36	35.98	27.78
	Staphylococcus epidermidis	29.83	32.58	23.02
	Klebsiella spp	21.55	21.21	23.02
	Pseudomonas spp	11.05	7.58	19.05
	Escherichia coli	2.21	2.65	6.35
Offal	*Staphylococcus aureus*	38.93	42.21	31.15
	Staphylococcus epidermidis	29.33	25.40	27.05
	Klebsiellaspp	17.07	23.36	20.23
	Pseudomonas spp	11.20	9.02	15.57
	Escherichia coli	3.67	-	-

Table 7. Frequency of Occurrence of Bacteria Isolates in Muscles and Offal from Bulls

Type of Meat	Bacteria	Frequency of occurrence (%) / Week		
		0	2	4
Muscles	*Staphylococcus aureus*	49.59	31.17	32.41
	Staphylococcus epidermidis	31.71	25.51	28.97
	Klebsiellaspp	10.57	27.94	14.48
	Pseudomonas spp	6.50	3.24	14.48
	Escherichia coli	1.63	12.15	9.65
Offal	*Staphylococcus aureus*	35.48	39.09	33.58
	Staphylococcus epidermidis	28.23	24.28	35.58
	Klebsiellaspp	16.13	18.93	12.41
	Pseudomonas spp	20.16	10.29	13.87
	Escherichia coli	-	7.41	6.57

Table 8. Frequency of Occurrence of Bacteria Isolates in Muscles and Offal from Goats

Type of Meat	Bacteria	Frequency of occurrence (%) / Week		
		0	2	4
Muscles	*Staphylococcus aureus*	27.68	41.67	37.96
	Staphylococcus epidermidis	23.25	28.51	24.82
	Klebsiellaspp	8.49	5.26	21.90
	Pseudomonas spp	12.18	14.47	9.49
	Escherichia coli	28.41	10.09	5.84
Offal	*Staphylococcus aureus*	35.71	38.58	31.15
	Staphylococcus epidermidis	27.04	28.74	34.59
	Klebsiellaspp	14.80	18.90	22.95
	Pseudomonas spp	17.86	13.78	21.31
	Escherichia coli	4.59	-	-

Table 9. Frequency of Occurrence of Bacteria Isolates in Muscles and Offal from Camels

Type of Meat	Bacteria	Frequency of occurrence (%) / Week		
		0	2	4
Muscles	*Staphylococcus aureus*	33.64	31.40	27.14
	Staphylococcus epidermidis	28.64	35.15	28.57
	Klebsiellaspp	18.64	17.06	2.00
	Pseudomonas spp	17.27	13.65	16.43
	Escherichia coli	1.81	2.73	7.86
Offal	*Staphylococcus aureus*	40.10	37.96	20.90
	Staphylococcus epidermidis	27.60	21.63	34.33
	Klebsiellaspp	16.15	18.78	29.11
	Pseudomonas spp	14.06	11.02	11.94
	Escherichia coli	2.03	10.61	3.37

(2017). These workers did not only refer to *Staphylococcus aureus* as the most frequently isolated bacteria, but also the one with the highest percentage of occurrence in those meat and meat products. However, this contradicts the

findings of Moshood et al. (2012), Manyi et al. (2014), Samuel et al. (2015) and Uzeh et al. (2012) who identified *E. coli* as the most frequently occurring bacterial isolates in meat and its products. Finally, the fact that *E. coli* occurred less in frequency in the present study completely in agreement with the findings of Nwakanma et al.(2015), Lawrence et al. (2016) and Falegan et al. (2017), but, however, disagrees with those of Edema et al. (2008), Ogbonna et al. (2012), Samuel et al.(2015) and Ananias et al.(2017). *Staphylococcus aureus* and *E. coli* are not however, to be tolerated in large numbers particularly in ready-to-eat meat products such as the *Sallah* meat.

Conclusion

Although the microbial counts recorded in this study were below the safety levels of 10^2 to< 10^3 recommended by the Center for Food Safety for ready-to-eat meats, the study concludes that the high frequency in occurrence of *Staphylococcus aureus* in the samples investigated is a serious public health concern. The practice of storing the fried *Sallah* meat for an extended period at ambient temperatures should be discouraged, due to the fact that the fried meats and the offal are not packaged and re-heated prior to their consumption.

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REFERENCES

Abdullahi FS, Igwegbe AO, Bello AB, Abashe S, Adam IK, Badau MH. (2019). Assessment of Microbial Quality of Balangu-Dipping Water from Six Outlets in Wudil Town in Kano State, Nigeria. Int. J. Food Sci. Technol. 9(2): 1 – 12.

Adak GK, Meakins SM, Yip H, Lopman BA, O'brien SJ. (2005). Disease risks from foods, England and Wales, 1996–2000. Emerg. Infect. Dis. 11**:** 365 - 371.

Adam MR, Moss MO. (2007). Food Microbiology. New Age Int. Publishers, New Delhi, India.

Adeyeye SA. (2016). Quality and safety assessment of sun dried meat product (*kundi*) from Ibadan, Oyo state, Nigeria. Cog. Food Agric. 2(1): 1209074

Ananias B, Roland K. (2017). Bacterial contamination of ready-to-eat meat vended in highway markets in Uganda. Afric. J. Food Sci. 11(6): 160-170.

Banwart G. (2012). Basic food microbiology. Springer Science and Business Media, USA.

Biesalski HK, Nohr D. (2009). The nutritional quality of meat. In: J.P. Kerry and D. Ledward (Eds). Improving the Sensory and Nutritional Quality of Fresh Meat, 1st Edn. Woodhead Publishing Ltd, Cambridge, England.

Calkins CR, Hodgen JM. (2007). A fresh look at meat flavour. Meat Sci. *77*(1): 63 - 80.

Center for Food Safety, (2007). Microbiological Guidelines for Ready-to-eat Foods. Centre for Food Safety and Environmental Hygiene Department, 66 Queensway, Hong Kong.

Cheesbrough M (2006). District Laboratory Practice in Tropical Countries, 2nd Edn.,Cambridge university press. Cambrigde,UK.,pp 47-54.

Clarence SY, Obinna CN, Shalom NC. (2009). Assessment of bacteriological qualityof ready to eat food (Meat pie) in Benin City metropolis, Nigeria. J. Microb. Res. 3(6): 390-395.

Dean A, Voss D, Draguljic D. (2017). Design and Analysis of Experiments. 2nd Edition, Springer International Publishing, New York. https://doi.org/10.1007/978-3-319-52250-0

Edema MO, Osho AT, Diala CI. (2008). Evaluation of microbial harzards associated with the processing of suya (a grilled meat product). Sci. Res. Essay. 3(12): 621-626.

Egbebi OA, Muhammed AA. (2016). Microbiological analysis of ready-to-eat suya meat sold in Owo, Ondo State, Nigeria. Int. J. Innov. Biochem. Microbiol. Res. 4(2): 11-15.

Falegan CR, Akoja SO, Oyarekua MA. (2017). Microbiological assessment of suya in Ado Ekiti metropolis, Ekiti State, Nigeria. MOJ Biol. Med. 2(3): 266-269.

Food Standards, Australia New Zealand (2002). Food Standards Code, Vol.2. Canberra: Information Australia.

Gilbert U, Harrison A. (2001). Occurrence of enterotoxin producing Staphylococcus aureus in meat market in Nigeria. J. Food Infect. 56: 25-35.

Heinz G, Hautzinger P. (2007). Meat Processing Technology for Small-to-Medium-Scale Producers. Food and Agriculture Organization (FAO) of the United Nations. Regional Office for Asia and the Pacific, Bangkok.

Igwegbe AO, Idakwo PY, Yusuf HL, Agbara GI, Maijalo AI, Abubakar F (2019a). Effects of sodium citrate and garlic on organoleptic properties, proximate composition, free fatty acid and thiobarbituric acid levels of treated smoke-died meat stored at ambient temperature. CPQ Med. 5(5): 2 – 14.

Igwegbe AO, Kassum AL, Maina FJ, Bristone C, Abubakar F, Imam HO, Lawan HK, Adam FM. (2019b). Effects of sodium citrate and garlic on pH and microbial stability of smoke-dried meat stored at ambient temperatures. In "Health, Environment and Sustaniable Development: A Book of Readings in Honour of Professor Ibrahim Njodi, Chapter 23" J. A. Opara (Ed.). University of Maiduguri Press, http://www.unimaid.edu.ng. Pp. 226–240.

Jay JM, Loessner MJ, Golden DA. (Eds.). (2005). Modern Food Microbiology, 7th Edition, Springer Science + Business Media Inc., New York, USA.

Kaferstein FK. (2003). Food safety: The fourth pillar in the strategy to prevent infant diarrhea. Bull. World Health Org. 81: 842–843

Lawley R, Curtis L, Davis J. (2012): The Food Safety Hazard Guidebook. RSC Publishing. London, UK: Pp. 70-74.

Lawrence OA, Faith OS, Ruth E, Nathaniel NN. (2016). Bacterial status and anti-bacterial susceptibility profiles of selected pathogens associated with Suya samples purchased in Bori, Metropolis, Rivers State, Nigeria. Int. Res. J. Pub. Environ. Health. 3(2): 14 - 19.

Leake LI. (2006). Water activity and food quality. Food Technol. 60: 62 – 67.

Macfaddin J. (2000).Biochemical Test for Identification of Medical Bacteria. 3rd ed. Liincott Williams and Wilkins, Philadelphia, PA. Pp: 55 - 78.

Manyi MM, Idu OF, Ogbonna IO. (2014). Microbiological and parasitic quality of Suya (rosted beef) sold in Makurdi, Benue State, Nigeria. Afr. J. Microbiol. Res. 8(35): 3235-3242.

Monson F, Sanudo C, Sierra I. (2005). Influence of breed and ageing time on the sensory meat quality and consumer acceptability in intensive reared beef. Meat Sci. 71: 471 - 479.

Moshood AY, Tengku HA, Ibrahim H. (2012). Isolation and identification of bacteria (roasted meat products) sold in Bauchi, Nigeria IOSR J. Pharm. 2(6): 38-48.

Nester EW, Aderson, DG, Roberts CE, Pearsall NN, Nester MT. (2001).Microbiology, A Human perspective, (3rd Edn), McGraw Hill Company, USA. Pp. 809-822.18.

Norrung B., Anderson JK, Buncie S. (2009). Main concerns of Pathogenic Microorganism in: Meat Safety and Processed Meats. F. Toldra (Ed.). Springer Science and Business Media, USA Pp: 3 – 29.

Nwakanma C, Unachukwu MN, Momoh OR. (2015). Bacteriological examination of suya meat sold in Enugu metropolis. World J. Pharm. Res. 4(12): 61-70.

Ogbonna IO, Danladi, MS, Akinmusire O, Odu CE. (2012). Microbiological Safety and proximate composition of suya stored at ambient temperature for six hours from maiduguri, Northern Nigeria. Internet J. Food Safety. 14: 11 - 16.

Olaoye OA, Onilude AA, Idowu OA, Technology B. (2010).Microbiological profil of goat meat inoculated with lactic acid bacteria cultures and stored at 3°C for 7days. Food Bioproc. Technol. 4(2): 312 – 319.

Olaoye OJ. (2011). Meat: An overview of its composition, biochemical changes and associated microbial agents. Int. Food Res. J. 18(3): 877 – 885.

Quinn PJ, Carter ME, Markey B, Carter GR. (2002). Clinical Veterinary Microbiology, Mosby International Ltd., London. Pp. 42 - 49.

Rao V, Thulasi G, Ruban SJ (2009). Meat quality characteristics of non descript buffalo as affected by age and sex. World Appl. Sci. J. 6**:** 1058 - 1065.

Reiman HP, Cliver DO. (Eds.) (2006). Foodborne infections and Intoxications, 3rd Edition. Elsevier Inc., London.

Roos YH, Finley JW, deMan JM. (2018). Water. In: Principles of Food Chemistry, 4th Edition. JM deMan, WJ Hurt, JW Finley, CY Lee (Eds.). Springer International Publishing AG. Cham. Switzerland. Pp: 1 – 38.

Samuel O, Obika I, Odibo F, Orji M. (2015). An assessment of the bacteriological quality of Tsire-Suya (Grilled Beef) sold in Awka, Nigeria. Ann. J. Life Sci. Res. 3(4): 287-292.

Shafiur Rahman M, Perera CO (2007). Drying and Food Preservation. In "Handbook of Food Preservation, 2nd Edition, M. Shafiur Rahman (Ed.). CRC Press, New York. Pp: 403-432.

Shaltout FA, Amin RA, Nassif MZ, Abd-elwahab SA (2014).Detection of aflatoxins in some meat products. Benha.Vet. Med. J. 27(2): 368 - 374.

Stanley MC, Obeagu EI, Ochei K. (2015). 'Evaluation of Microbial Contamination of Tools used in Hair Dressing Salons in Michael Okpara University of Agriculture, Umudike, Abia State, Wiszniewska M, Walusiak-Skorupa J. Recent Trends in Occupational Contact Dermatitis', Curr. Allergy Asthm. Res. 15: 1–11.

Thippareddi H, Sanchez M (2006). Thermal processing of meat products. In: Thermal Food Processing: New Technologies and Quality Issues. Sun DW. (Ed.), Taylor and Group CRC Press, New York. Pp: 156 – 192

Tijjani AO, Jumare S. (2014). Microbiological quality assessment of meat Samples sold in Kaura, Namoda. International Conference on Earth, Environment and Life Sciences December 23-24. Dubai, UAE.

Umoh JU. (2004). Critical control point of beef production to determine the microbial load of the meat. Food Res. 22: 80 - 85.

Uzeh RE, Akinyemi MO, Nduaguba CC (2012). Microbiological and physico chemical characteristics of stored Tsire-Suya, a roasted meat product. Int. J. Biol. Chem. Sci. 6(4): 1804 - 1809.

Vilar I, García Fontán M, Prieto B, Tornadijo M, Carballo JJ (2000). A survey on the microbiological changes during the manufacture of dry-cured lacón, a Spanish traditional meat product. J. Appl. Micrbiol. 89(6): 1018 - 1026.

Vipul V, Singh R, Tiwari RK, Srivastava N, Verma A. (2012). Antibacterial activity of extracts *of Citrus, Allium & Punica* against food borne spoilage. Asian J. Plant Sci. Res. 2 (4): 503 – 509.

WHO/UNICEF (2009) Diarrhoea: Why Children are Still Dying and What Can be Done. Available at: http://www.who.int/maternal_child_adolescent/documents/ 9789241598415/en/ (accessed on 30th May 2016).

Yusuf A, Abdulhamid T, Hussain, IJ. (2012). Isolation and identification of bacteria associated with balangu (roasted meat product) sold in Bauchi, Nigeria. J. Pharm. 2(6): 38 - 39.

Yusuf HL, Igwegbe AO, Idakwo PY, Ismail BB (2019). Process Standardization using Sensory Evaluation of *Kamsa*: A Smoked-dried Meat. In "Proceedings of the 43rd Conference of the Nigerian Institute of Food Science and Technology, 14 – 18th October, Awka Anambra State, Nigeria. PP: 3-4.

Zukal E, Incze K. (2010). Drying. In : Handbook of Food Processing/ Chapter 11. Fidel T. (Ed.). Wiley-Blackwell: A John Wilaey and Sons, Inc. Publication, Iowa, USA. Pp: 219 -229.