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# Isolation of bacteria and fungi of medical importance from beef jerky (Kilishi) sold in Uyo, Akwa Ibom State, Nigeria

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## ABSTRACT

Beef jerky (Kilishi) is a good source of protein for man. However, some microorganisms contaminate this product and sometimes cause food-borne illnesses. This research was conducted to isolate bacteria and fungi of medical importance from beef jerky sold in Uyo, Akwa Ibom State, Nigeria. Samples of beef jerky were purchased from 6 selected supermarkets within the Uyo metropolis. The samples containers were carefully labeled and transported to Microbiology laboratory, Department of Microbiology, University of Uyo for analyses. Proximate and microbiological analyses were carried out using standard techniques. Beef jerky sampled had moisture content (0.5%), ash content (14.50%), crude lipid (5.9%), crude fibre (2.88%), protein content (54.69%, carbohydrate content (21.46%) and caloric value (601.93Kcal). *Escherichia coli, Proteus species. Staphylococcus aureus, Citrobacter fruendii, Klebsiella* pneumonia, *Staphylococcus epidermidis, Aspergillus niger*, *Penicillium species* and *Rhizopus species* were isolated. The total heterotrophic bacterial counts (THBC) obtained ranged from 2.0 x$10^3$ - 8.0x$10^3$ CFU/g, total coliform count (TCC) ranged from 1.0x$10^3$ - 6.0x$10^3$ CFU/g, total faecal coliform count (TFC) ranged from 1.0x$10^3$ - 5.0x$10^3$ CFU/g, total staphylococcal count (TSC) ranged from 2.0x$10^3$ - 9.0x$10^3$CFU/g and total mycological count ranged from 1.0x$10^3$ - 4.0x$10^3$ CFU/g. All bacterial isolates were sensitive to Ceptazidime with zones of inhibition (Z.I) ranged from 15±0.4mm - 40±0.4mm. Isolate $B_2$ (*Escherichia coli*) was resistant to all antibiotics except Ceftazidime. No zones of inhibition (NZ) were recorded for some isolates. Voriconazole had highest ZI of 25±3.2mm on *Aspergillus niger*. Proper hygienic condition is vital for reducing microbial contamination on beef jerky.

**Keywords:** Beef jerky, bacteria, fungi, contamination, illnesses.

## 1. INTRODUCTION

Meat and meat related products such as beef jerky (Kilishi) have been consumed by man from time immemorial and it is a good source of protein. This class of food helps to build and maintain humans' bodies. This fact has also led to the domestication of animals like pigs, goats, sheep and cattle [1]. According to [2] the word "jerky" came from the Spanish word "charque" meaning 'dried piece of meat'. Jerky is historically one of the oldest forms of preserved meat by curing and drying to reduce water and this prevent or reduce the growth of microorganisms [3]. According to [4], Jerky is a traditional food that has been known and consumed by human beings since ancient Egypt. Jerky is loved by people because it is a nutrient-dense meat product, very easy to prepare, light–weighted and has a stable shelf life without refrigeration [5,6] Different types of meats such as pork, poultry, beef could be used to produced jerky but the one that is most common and widely prepared is beef jerky [7].

Beef jerky (Kilishi) however is a highly perishable product and if not well prepared and preserved is capable of rancidity and putrefaction in a matter of hours to days; hence the concept of drying meat as a method of preservation was adopted. According [8] in Nigeria, the early Hausa's practiced preparation of beef jerky by method of preservation in spectacular way by trimming fat and bone from thin slices of high quality beef and sun drying, after which certain spices and preparations like groundnut cake are added to improve the quality, taste and shelf life of the product. It is this product overtime that came to be known as "kilishi" a favorite delicacy among the Northerners and other people in Nigeria. Moreover, solar drying and salting are used traditionally to preserve this meat; these methods help to retain the quality of meat. These two methods of meat preservation are employed by kilishi processors [9]

Beef jerky are produced at the Northern parts of Nigeria and brought for sale by some supermarket dealers. That is why beef jerky (Kilishi) is not commonly found in Uyo. Beef jerky because of its dry nature and method of preparation is capable of lasting for months without going bad. Nevertheless, microorganisms can find themselves into this product because of their versatility and ubiquitous nature that enables them to thrive even under unfavorable conditions and their presence is of medical importance. Hence the objective of the work was to isolate bacteria and fungi of medical importance from beef Jerky (Kilishi) sold in Uyo, Akwa Ibom State, Nigeria.

## 2. MATERIALS AND METHODS

### 2.1 Collection of Sample:

Samples of beef jerky (Kilishi) were found and purchased from six (6) supermarkets located within the Uyo metropolis. The containers were carefully labeled to reflect places of collections. The samples were transported Uyo to the Microbiology laboratory, Department of Microbiology, University of Uyo, for proximate and microbiological analysis using standard technique.

### 2.2 Proximate analysis:

The containers were aseptically opened and samples were cut using sterile forcep and knife into sterile containers. The proximate analysis was carried out to determine moisture content, ash content, crude lipid, crude fibre, protein and carbohydrate. The methods of [10] were adopted with slight modification. The moisture content was determined as the loss in weight that results from drying a known weight of the food sample at $100^0$C. The ash content was determined by the ignition of a known weight of the food sample at $550^0$C until all carbon has been removed. The crude protein content was determined by Kjeldal method and was calculated from the nitrogen content of the food and it involved a stepwise digestion of the food substance using chemical reagents (sulphuric acid, sodium hydroxide), the end product which was ammonia was measured using standard colorimetric method. The crude lipid was determined by hydrolytic methods and the resultant residue was subjected to successive treatments with boiling acid and alkali respectively and at defined concentration; the organic residue was the crude fibre. The carbohydrate content was determined as nitrogen free extract (NFE). The percentage carbohydrate was estimated as the difference between 100 and the sum total of all the proximate composition of each sample.

### 2.3 Microbiological analysis:

Ten (10) grams of each sample of beef jerky was carefully blended using a sterile blender (Lab Blender 400 series, UK).The homogenized sample was then added to 90ml of distilled water and the vigorously shaken to dislodge adhered bacteria. Serial dilutions were made to obtain the required dilution factor [11]. One (1) ml of the serially diluted sample was transferred onto cultue plates of MacConkey Agar (Oxoid, USA), Nutrient Agar ((Oxoid, USA), Eosin Methylene Blue (Ovoid, USA), Cysteine Lactose Electrolyte Deficient agar (Difco Laboratories, Detroit, Mich), Mannitol salt agar ((Difco Laboratories, Detroit, Mich) and Sabourad Dextrose Agar (Difco Laboratories, Detroit, Mich) plates. The plates were incubated at $37^0$ C for 24hours for isolation of bacteria while SDA plates were kept for 1week at room temperature for isolation of fungi. After incubation, the colonies were counted to obtain the total heterotrophic bacteria counts (THBC), total faecal coliform counts (TFC), total coliform count (TCC), total staphylococcal count (TSC) and total mycological count (TMC). The number of colonies counted was multiplied by the reciprocal of the dilution factor to obtain the microbial load in colony forming unit per gram (CFU/g). The colonies were subcultured. Isolates were characterized and identified as described by [12, 13]. Pure culture of isolates were maintained in nutrient agar slant and stored in a refrigerator at $4^o$C for further analysis.

### 2.4 Antibiotic and antifungal susceptibility tests:

The susceptibility of bacteria isolates to different antibiotics and antifungal were performed by means of Kirby-Bauer disc diffusion method using the guidelines provided by [14]. Antibiotics used were; Ceftazidim, (30µl), Ciprofloxacin (5µl), Streptomycin (10 µl) and Gentamycin (10 µl) (Hardy diagnostic, USA). The susceptibility of fungal isolates to antifungal was also carried out using Fluconazole (25mcg), Nystatin (25mcg) and Voriconazole (1mcg) (Hardy diagnostic, USA). The bacterial isolates were sub-cultured on a freshly prepared Nutrient agar (Oxoid, USA) medium for 18-24 hours at 37ºC to obtain a young culture, each test organism was picked using a sterile wire loop and inoculated in 1ml of peptone water (Sigma chemical Co.Ltd, England.) and the organism was seeded on Mueller Hilton agar (Difco Laboratories, Detroit, Mich) plates. Cultures were done in triplicate. The plates were incubated at $37^0$C for 18-24 hours. The results were read by measuring in milliliter (mm) the resultant zones of inhibition with a transparent metre rule. The values recorded were the means of three

measurements of zones of inhibitions on the triplicate cultures their standard deviation. The Zone of inhibition (Z.I) values < 14mm is Resistant, Zone = 14mm is Intermediate, Zone ≥ 15mm is Sensitive.

## 3. RESULTS AND DISCUSSION

### 3.1 Proximate analysis of beef jerky (kilishi):

The result of the proximate analysis of beef jerky showed a very low moisture content of 0.5%, ash content of 14.50%, crude lipid content was 5.97%, crude fibre content of 2.88% , protein content of 54.69%,carbohydrates content of 21.46% and a total Caloric value of 601.93Kcal (Table 1).

### 3.2 Microbial counts obtained from beef jerky samples:

The total heterotrophic bacterial counts (THBC) obtained from beef jerky (kilishi) samples from different supermarkets ranged from 2.0 x$10^3$ to 8.0x$10^3$ CFU/g, the total coliform count (TCC) ranged from 1.0x$10^3$ to 6.0x$10^3$ CFU/g, total faecal coliform count (TFC) ranged from 1.0x$10^3$ to 5.0x$10^3$ CFU/g, total staphylococcal count (TSC) ranged from 2.0x$10^3$ to 9.0x$10^3$CFU/g and total mycological count ranged from 1.0x$10^3$ to 4.0x$10^3$ CFU/g. Beef jerky samples from some supermarkets had no faecal coliform count as well as coliform count and had no staphylococcal count. Samples from Richway supermarket had no staphylococcal and mycological counts. However, the THBC of 8.0x103 CFU/g was obtained from beef jerky samples from Olympic supermarket, the highest TFC of 5. 0x$10^3$ CFU/g was recorded from Olympic and Shop and Save supermarket. The highest total coliform count of 6.0x$10^3$ CFU/g was obtained from beef jerky samples from Oxford supermarket and the highest total staphylococcal count of 9.0x$10^3$ $^{CFU}$/g was obtained from samples from Shop and Save supermarket while TMC of 4.0x$10^3$ CFU/g was recorded from Oxford supermarket (Table 2).

**Table 1:** Proximate analysis of dried meat (kilishi)

| Parameters | Values (%) |
|---|---|
| Moisture content | 0.5% |
| Ash content | 14.50% |
| Crude lipid | 5.97% |
| Crude fiber | 2.88% |
| Protein | 54.69% |
| Carbohydrate | 21.46% |
| Caloric value | 601.93Kcal |

**Table 2:** Bacterial Counts obtained from beef jerky (CFU/g)

| Samples locations | THBC | TFC | TCC | TSC | TMC |
|---|---|---|---|---|---|
| Rich way supermarket | 5.0x$10^3$ | 3.0x$10^3$ | 2.0x$10^3$ | - | - |
| Olympic supermarket | 8.0x$10^3$ | 5.0x$10^3$ | 3.0x$10^3$ | 2.0x$10^3$ | 1.0x$10^3$ |
| Shop and save | 2.9x$10^3$ | 5.0x$10^3$ | 2.0x$10^3$ | 9.0x$10^3$ | 2.0x$10^3$ |
| Central supermarket | 2.0x$10^3$ | 1.0x$10^3$ | 1.0x$10^3$ | - | 1.0x$10^3$ |
| Oxford supermarket | 3.1x$10^3$ | 1.0x$10^3$ | 6.0x$10^3$ | 2.0x$10^3$ | 4.0x$10^3$ |
| God's time supermarket | 3.4x$10^3$ | - | - | 1.0x$10^3$ | 2.0x$10^3$ |

Keys: All values are CFU/g (colony forming unit per gram)
THBC: Total heterotrophic bacterial counts;
TFC: Total feacal Coliform count;
TCC: Total Coliform count
TSC: Total staphylococcal count
TMC: Total mycological count

### 3.3 Percentage occurrence of bacterial isolates obtained from beef jerky:

The results show that *Escherichia coli* had a percentage occurrence of 10%, *Staphylococcus aureus* had 20%, *Proteus spp.* as the predominant bacterial species in beef jerky sampled with a percentage occurrence of 35%, *Citrobacter fruendii* and *Klebsiella pneumonia* had 15% respectively while *Staphylococcus epidermidis* had the least with 5%. (Table 3).

**Table 3:** Percentage occurrence of bacterial isolates obtained from beef jerky

| Bacterial isolate | Number of occurrence | % occurrence |
|---|---|---|
| *Escherichia coli* | 2 | 10% |
| *Staphylococcus aureus* | 4 | 20% |
| *Proteus spp.* | 7 | 35% |
| *Citrobacter fruendii* | 3 | 15% |
| *Klebsiella pneumonia* | 3 | 15% |
| *Staphylococcus epidermidis* | 1 | 5% |
| Total | 20 | 100% |

### 3.4 Percentage occurrence of fungal isolates obtained from beef jerky sampled:

The results showed *Penicillium spp.*as the predominant fungal species in the beef jerky sampled with a percentage occurrence of 50%, Aspergillus *niger* 33.3% and *Rhizopus spp*. was the least with 16.7% (Table 4).

**Table 4:** Percentage occurrence of fungal isolates obtained from beef jerky

| Fungal isolate | Number of occurrence | % occurrence |
|---|---|---|
| *Aspergillus niger* | 2 | 33.3% |
| *Proteus* spp | 3 | 50% |
| *Rhizopus* spp. | 1 | 16.7% |
| Total | 6 | 100% |

### 3.5 Antibiotic susceptibility profile of bacterial isolates:

All Twenty (20) strains of bacterial isolates (E.coli, *S.aureus, S.epidermidis, C.fruendii, Proteus spp. And K.pnuemonia*) obtained in the study were sensitive to Ceptazidime and the zones of inhibition (ZI) ranged from 15±0.4mm to 40±0.4mm.M1 *(S.epidermidis)* isolate was sensitive to all the antibiotics with ZI that ranged from 14 ± 1.1mm to 36 ± 2.5mm, $B_2$ (*Escherichia coli*), was resistant to all antibiotics except Ceftazidime with a zone of inhibition of 17±1.4mm,C1 *(Proteus spp)* isolate was found to be sensitive to all antibiotics used in the study with ZI ranged from 15 ± 3.9mm - 26 ± 1.1mm but expressed resistance to Streptomycin with ZI of 12 ± 1.1mm, $N_2$ (*Citrobacter fruuendii*) was resistant to Streptomycin with no zones of inhibition (NZ) but sensitive to Gentamycin, Ceftazidime and Ciprofloxacin with a zone of inhibition ranging from 16±0.4 to 25±1.1mm, isolate $M_2$ (*Staphylococcus aureus*) was resistant to Ciprofloxacin but sensitive to Gentamycin, Ceftazidime and Streptomycin with a range of zone of inhibition of 15±0.4 to 23±0.4mm (Table 5).

**Table 5:** Result of Antibiotic Susceptibility Testing

| Isolate code | Bacterial isolates | CIP (ZI in mm) | STR(ZI in mm) | CEP(ZI in mm) | GEN(ZI in mm) |
|---|---|---|---|---|---|
| M1 | *S.epidermidis* | 36 ± 2.5 | 14 ± 1.1 | 33 ± 1.1 | 23± 0.4 |
| M2 | *S.aureus* | NZ | 18 ± 1.1 | 15 ± 0.4 | 23 ±0.4 |
| C1 | *Proteus spp.* | 26 ± 1.1 | 12 ± 1.1 | 15 ± 3.9 | 25 ±0.4 |
| C2 | *Proteus spp.* | 31 ± 1.1 | 20 ± 2.5 | 21 ± 0.4 | 29± 0.4 |
| C3 | *Proteus spp.* | 15 ± 3.2 | 16± 1.1 | 22 ± 1.1 | 16 ±1.1 |
| C4 | *Proteus spp.* | 23 ± 4.6 | 15 ±2.5 | 15 ± 1.1 | 21 ±1.8 |
| N1 | *Proteus spp.* | 27 ± 1.1 | 14 ±1.8 | 24 ± 0.4 | 25 ± 0.4 |
| N2 | *C.fruendii* | 22 ± 3.9 | NZ | 25 ±1.1 | 16 ± 0.4 |
| N3 | *C.fruendii* | 24 ± 2.5 | 19 ± 1.1 | 17 ±1.8 | 24± 0.4 |
| M3 | *S.aureus* | 24 ± 1.1 | 21 ± 1.1 | 19± 0.4 | 22± 1.8 |
| B1 | *K.pneumonia* | 25 ± 1.1 | 14 ± 1.1 | 28± 1.1 | 19 ± 2.5 |
| B2 | *E.coli* | NZ | NZ | 17 ± 1.4 | NZ |
| B3 | *E.coli* | 34 ± 6.0 | 16 ± 3.2 | 32 ± 5.0 | 15± 0.4 |
| B4 | *K.pneumonia* | 27 ± 1.1 | 16 ± 1.8 | 32± 3.9 | 14± 3.2 |
| B5 | *Proteus spp.* | 27 ± 1.1 | 16 ± 0.4 | 25 ± 0.4 | 22 ± 1.1 |
| B6 | *S.aureus* | 30 ± 0.34 | 13± 3.9 | 30 ± 2.5 | 22 ± 0.4 |
| B7 | *S.aureus* | 31 ± 1.8 | 17 ± 1.8 | 30± 2.5 | 22 ± 0.4 |
| B8 | *C.fruendii* | 21 ± 0.4 | 19 ± 0.4 | 34± 2.5 | 24 ± 1.8 |
| B9 | *Proteus spp.* | 37 ± 1.1 | 21 ± 1.1 | 40 ±0.4 | 29± 0.4 |
| B10 | *K.pneumonia* | 33 ± 1.1 | 18± 0.4 | 35 ± 0.4 | 26 ± 1.1 |

Note: All measurements are in millimeters (mm) and the results are expressed in the mean of the zone of inhibitions ± standard deviation. Zone of inhibitions (ZI) < 14mm is Resistant, ZI = 14mm is Intermediate, ZI ≥ 15mm is Sensitive

**Keys:** CEP: Ceftazidime, CIP: Ciprofloxacin, STR: Streptomycin, GEN: Gentamycin

### 3.6 Antifungal susceptibility profile of fungal isolates:

Antifungal sensitivity test showed that *Aspergillus niger* was most sensitive to Fluconazole with a zone of inhibition of 24±3.2mm and least sensitive to Nystatin 18±1.1mm, *Rhizopus sp.* was most sensitive to Voriconazole with a zone of inhibition of 23±0.4mm and resistant to Nystatin with a zone of inhibition of 11±1.1mm, *Penicillium sp*. was most sensitive to Nystatin 26±3.9mm. None of the fungal isolates were resistant to the chosen anti-fungal agents (Table 6).

**Table 6:** Result on antifungal susceptibility testing

| Isolate code | Fungal isolate | FLU(ZI in mm) | NYS(ZI in mm) | VOR (ZI in mm) |
|---|---|---|---|---|
| F1 | *Aspergillus niger* | 24±1.1 | 21±1.1 | 25±3.2 |
| F2 | *Penicillium spp.* | 23±3.2 | 26±3.9 | 22±3.2 |
| F3 | *Rhizopus spp.* | 12±1.1 | 11±1.1 | 23±0.4 |
| F4 | *Penicillium spp.* | 23±1.1 | 19±1.8 | 19±3.9 |
| F5 | *Aspergillus niger* | 24±3.2 | 18±1.1 | 21±1.1 |
| F6 | *Penicillium spp.* | 13± 1.1 | 11±1.1 | 23±0.4 |

Note: All measurements are in millimeters (mm) and the results are expressed in the mean of the zone of inhibition ± standard deviation
Zones of inhibitions (ZI) < 14mm = Resistant, Zone = 14mm = Intermediate, Zone ≥ 15mm = Sensitive
**Keys**: FLU: Fluconazole, NYS: Nystatin ,VOR: Voriconazole

The moisture content of beef jerky in this study was 0.5% which was low as compared to the work of [15] who reported that the moisture content of beef jerky ranged from 9.92% to 10% depending on the type of meat used. The low moisture value obtained is as a result of the rigorous and stepwise drying involved in the kilishi production process and according to [16], jerky products need to have a stable water activity and this as to do with moisture content so as to avoid changes in quality during storage. Moreover, reports from [17] stated that the moisture content of the dried sliced meat samples (kilishi) varied depending on the producer. The crude protein value and values for other parameters from proximate analysis also varied considerably as compare to the report of [15]. They differences in these parameter may likely come from the animals used in the beef jerky production as well as a result of the spices and additives used in making the meat product.

In this study, there was minimum detection of growth of bacteria as of as low as 1.0 x $10^2$ CFU/g for TFC, and the highest values of 9.0 x $10^2$ CFU/g TSC other microbial counts were observed that they all fell within the acceptable standard of 1.0x$10^5$ CFU/g set by the International Commission of Microbiological Specifications for Foods [18]. Although there has been a large debate concerning the limit for the total viable bacteria count in a meat product especially at the point of consumption, Reports by [18] put the limit between 2.5 x $10^5$ to 1.0 x CFU/$10^8$/g of consumable meat products. Moreover, [19] reported that the presence of these organisms on kilishi could be attributed to the nature of which meat has an abundance of all nutrients required for bacterial growth in adequate quantity. Similarly, [20] reported that the low microbial counts in jerky could be as result of low water activity (aw) that inhibited microbial growth. The high THBC and TSC recorded in this study showed the microbial diversity in the Northern parts of the Country where this product is produced, the hygienic practice employed by butchers, the kilishi processors, handlers, packaging as well as storage condition in individual supermarket in Uyo. Work by [21] reported that the findings concerning kilishi from different locations varied in microbial count and diversity.

The presence of *E.coli* in the beef jerky studied is of public health [22] reported that *E. coli* is commonly used as surrogate indicator, its presence in food generally is traceable to feacal contamination either directly and indirectly They also stated that *E. coli* is a normal flora of intestine in human and animals and is widely distributed in the environment contaminating food and water and their presence in foods are usually as a result of excessive human handling [22] It is of public health concern considering the role of *E.coli* in food borne infection [23] Some strains of this pathogen can cause a wide variety of infections such as diarrhea and other gastrointestinal problems in hospitals and community setting [24] and these infections continue to cause illness, complications and death especially among children in most parts of the world [25] The presence of *Staphylococcus aureus and Staphylococcus epidermidis* in the beef jerky studied is an indication of possible contamination from human sources as both bacterial species are normal flora of the skin of man and can be transmitted from person to product through unhygienic practices [26]. According to [27], enterotoxin producing strains of *S. aureus* is a leading cause of food intoxication, it is an extremely potent gastrointestinal toxin and as little as 100ng (nanograms) is sufficient to cause symptoms of intoxication [28]. Thus isolation of *S. aureus* is worrisome. Moreover, the presence of *Proteus* spp. in the sample could be due to humans, animals, soil or water contamination during the processing of kilishi [29] reported that members of the genus *Proteus* occur widely in man, animals and in the

environment and can be readily and easily isolated from sewage, soil, garden vegetables and many other materials [30] reported that species of *Proteus* as less frequently strains in kilishi but [31] reported the isolation of *Proteus* from killishi in three locations they sampled it is therefore very vital to control the distribution of these organisms since the sources of infection are many. Contamination by *Klebsiella pneumonia* could arise from food handlers' phenomena as the bacteria is resident in the mouth and oral cavity of human beings and the isolation of *Klebsiella* species from ready-to-eat dried sliced meat sample is an indication of possible post production contamination as these organisms are expected to have been destroyed during the high temperature treatment of roasting and drying [21]. *Citrobacter fruendii* was also isolated from the beef jerky sampled and its presence is not surprising because work by [30] reported that the most frequently coliform identified on meat products are *C. freundii* and *E. coli* and this could be attributed to the contamination of water used in the preparation of kilishi or contamination of carcasses in the abbatoirs.

The presence of fungi isolates especially *Aspergillus niger* and *Penicillium spp* is of clinical significance because of the production of their toxin such as aflatoxin by *Aspergillus niger* and consumption of *Penicillium spp* in food must be avoided, since it can lead to allergic reactions and arising of penicillin resistance in human pathogenic bacteria. [32]. All fungal isolates obtained are known to cause deterioration of food and human diseases such as ostomycosis (fungal ear infection caused by *A.niger*) and zygomycosis (fungal infection of the face and oropharyngeal cavity caused by *Rhizopus spp*. Moreover, [33] reported *Rhizopus spp.* as the second most common fungal pathogen responsible for the skin and gastrointestinal forms of mycosis; The onset of the disease which can be rapid and includes the invasion of blood vessels, causing thrombs and tissue necrosis.

The presence of fungi in the meat product could arise from environmental sources as the spores are known to survive in the environment. The beef jerky product might have been exposed contamination by the fungal spores. According to [34], poor storage of the meat product is also a factor as it is not uncommon for meat sellers to store these products in moldy jute or raffia bags. Reported by [35] showed that the health status of animals prior to slaughtering and the prevailing circumstance in the slaughter as well other factors such as storage contribute to the quality of meat from such animals and according to [21,19] ,the extent to which this meat product is contaminated by microorganisms is dependent on the level of hygiene of the people involved and materials used in the production chain. Observations by [36] showed that slaughtering of animals usually takes place under very unhygienic conditions particularly in rural communities and small towns. This, coupled with the high ambient temperature, high humidity, shortage of portable water and poor handling practices disposes meat product to microbial contamination as well as rapid deterioration This fact which are obvious especially in the Northern part of the Country where this beef jerky is produced.

The multidrug resistance patterns observed in the study especially from isolates *E. coli*, *S. aureus* and *C. fruendii* isolates these phenomena could be mediated by genetic mutation or plasmid transfer among antibiotic resistant microbial strains, thus kilishi could be a source of food borne disease outbreak in a community at large. None of the fungal isolates obtained were resistant to the chosen antifungal agents [37] reported that the routine and indiscriminate use of antibiotics in both medical and veterinary medicine has resulted in wide spread antibiotic resistance and development of antibiotic resistance genes especially within the gram negative organisms.

## 4. CONCLUSION

The multiple numbers of bacterial pathogens isolated from beef jerky samples from the Supermarket in Uyo metropolis implies that this meat product could be a potential source of infection if not checked. The presence of microorganisms of medical importance which are potentially life threatening pathogens indicates the potential health hazard faced by the consumers of this product. The processors/handlers/sellers should practice strict hygienic measures right from when the meats is fresh, during drying procedures, spicing, packaging, and storage so as to avoid introducing any contaminant into the product. Moreover, public health workers and relevant authorities concerned should educate beef jerky processors, handlers, sellers as well as the public on the proper food hygiene so as to avoid contamination of the beef jerky thus preventing food borne illnesses.

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## 5. REFERENCES

1. Lawrie RA, Ledward DA. *Lawrie's meat science* (7th edition). Cambridge: woodhead publishing limited 2006: pp 1-14
2. FSIS (2011) Jerky and Food safety. Food Safety and Inspection Service, United States Department of Agriculture, Washington, DC, USA. Available from: http://www.fsis.usda.gov/Fact_Sheets/Jerky_ and_Food_Safety/index.asp#1. Modified Nov. 15, 2011
3. Choi JH, Jeong JY, Han DJ et al. (2008). Effects of pork/beef levels and various casings on quality properties of semi-dried jerky. Meat Sci. 71: 278-286.
4. Dong-Gyun L, Sang-Suk L, Kang-Seok S et al.( 2012). Effects of Different Drying Methods on Quality Traits of Hanwoo Beef Jerky from Low-Valued Cuts during Storage. Korean J. Food Sci. An. 32: ( 5)531~539
5. Fernández-Salguero J, Gómez R, Carmona MA. (1994). Awof Spanish intermediate-moisture meat products. Meat Sci. 38: 341-346.

6. Yoon Y, Calicioglua, M, Kendallb PA et al. (2005). Influence of inoculum level and acidic marination on inactivation of Escherichia coli O157:H7 during drying and storage of beef jerky. Food Microbiol. 22:423-431.
7. Lee SW, Kang CS.(2003). Effects of moisture content and drying temperature on the physicochemical properties of ostrich jerky. Nahrung Food. 47:330-333.
8. Jones MJ, Tanya VN, Fonkem DN et al (2001). A microbial and nutritional evaluation of the west African dried meat product, kilishi. J. food tech. Afr. 6 (4): 126-129.
9. Omojola AB, Isah OA., Adewumi MK et al. (2003). Evaluation of the effects of various additives on the acceptability of kilishi. Trop. J. Anim. Sci. 6(2): 97-101
10. AOAC (2000) Official methods of analysis (17th ed.). Gaithersburg, MD: Association of Official Analytical Chemists 2000
11. Fawole MO, Oso BA. Laboratory manual of Microbiology: Revised edition spectrum books Ltd, Ibadan, 2001: 127.
12. Holt JG, Krieg NR, Sneath PHA, Staley JT, Williams ST. Bergeys manual of determinative bacteriology(9th ed.) The Williams and Wilkins Company Baltimore, Maryland, U.S.A. 1994: Pp 560-980
13. Cheesbrough M. Medical Laboratory Manual.Tropical Health Technology, Low priced Edition. Doddington, Cambridgeshire, England, 2003: pp. 20-35.
14. Clinical and Laboratory Standards Institute. Performance standards for antimicrobial susceptibility testing. *Fifteenth informational supplement. CLSI document M100-S15 Wayne, PA.2006*
15. Ogunsola OO Omojola AB. (2008). Qualitative evaluation of kilishi prepared from beef and pork. *Afri J. Biotech*. 7(11): 1753-1758
16. Yamaguchi, N., Naito, S., Okada, Y et al. (1986) Effect of oxygen barrier of packaging material on food preservation. Annual Report of the Food Research Institute, 27.Japan: AichiPrefecture Government. 69-73.
17. Okonko IO, Ogunjobi AA, Fajobi EA et al.(2008b) Comparative studies and microbial risk assessment of different Ready-to-Eat (RTE) frozen sea-foods processedin Ijora-olopa, Lagos State, Nigeria. African J.Biotech.7(16): 2898-2901
18. ICMSF. (2011) Microorganisms in Foods: use of Data for Assessing process control and product Acceptance. 2011
19. Okonko IO, Odu NN, IGBOH IE. (2013) Microbiological Analysis of Kilishi Sold In Port Harcourt, Nigeria. New York Sci J. 6 (7):37-43].
20. Torres EAFS., Shimokomaki M, Franco, BDGM et al. (1994) Parameters determining the quality of charqui, an intermediate moisture meat product. Meat Sci. 38, 229-234
21. Raji AI. (2006) Bacteriological quality of dried sliced beef (Kilishi) sold in Ilorin Metropolis. Journal of Applied Science and Environmental Management . 10:97-100.
22. Clarence SY, Obinna CN, Shalom NC.(2009) Assessment of bacteriological quality of ready to eat food (Meat pie) in Benin City metropolis,Nigeria. Afr. J. Microb. Res.3(6): 390-395
23. Doyle MP, Erickson MC. (2006). "Reducing the carriage of foodborne pathogens in livestock and poultry". Poul Sc. *85* (6): 60-73.
24. Donnenberg MS, Mandel GL, Bennett JE et al. Enterobacteriaeace principles and practice of infectious Diseases 6th edition Elsevier Churchill Livingstone Publishers, Philadephia, 2005: 267-286
25. Ternhag A, Törner A, Svensson Å et al.(2008) Short- and long-term effects of bacterial gastrointestinal infections. Emerging Infectious Diseases. http://www.cdc.gov/EID/content/14/1/143.htm
26. Tauxe R. (2002). Emerging food borne pathogens. Intl. J. Food Microbio. 78:31-41
27. Nema V, Agrawal R, Kamboj DV et al (2007). "Isolation and characterization of heat resistant enterotoxigenic Staphylococcus aureus from a food poisoning outbreak in Indian subcontinent". *Int. J. Food Microbiol*. 117 (1): 29-35.
28. Evenson MI, Hinds MW, Bernstein RS et al.(1988) Estimation of human dose of staphylococcal enterotoxin A from a large outbreak of staphylococcal food poisoning involving chocolate milk. Int. J. Food Microbiol. **7:**311–316
29. Gus Gunzalez B, Bronze MS, Drevets DA et al.(2006) http://www.emedicine.com/MED/topic1929.htm.
30. Turtura GC. (1991). Enterobacteriaceae and other gram negative bacteria in slaughtered poultry.Microbiol Ail. Nutr. 9(2):139-146
31. Okwori AEJ, Obioha C, Olabode AO et al. (2009).Bacteriology of dried meat (Kilishi) hawked in some Northern Nigerian Cities Nig. J. Biotech. 20; 1 – 6
32. Licorish K, Novey HS, Kozak P et al.(1985). Role of Alternaria and Penicillium spores in the pathogenesis of asthma. J Allergy Clin Immunol. 76(6):819-25 4.
33. Ribes JA, Vanover, CL, Baker DI.(2000) Zygomycetes in Human Disease.Clin Micrbiol. Rev. 13(2): 236–301
34. Ajiboye EA, Sani A, Adedayo R et al.(2011) Physicochemical properties and microorganisms isolated from dried meat obtained in Oja-Oba market in Ilorin, Nigeria. Adv. Applied Science Res.2(4): 391-400
35. Whyte P, McGill K, Cowley D et al.(2004) Occurrence of Campylobacter in Retail Foods in Ireland. Int J Food Microbiol. 1; 95(2):111-8
36. Bender A. (1992). Meat and meat products in human nutrition in developing countries. Commissioned jointly by the Animal Production and Health Division and the Food Policy and Nutrition Division of FAO, Rome
37. Enabulele SA, Uraih N.(2009). Enterohaemorrhagic *Escherichia coli* 0157:H7 Prevalence in meat and vegetables sold in Benin City, Nigeria. Afr. J. Microbiol Res. 3(5): 276-279.




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