



Virulent Factors' Profile of Bacteria, Isolated from Shawarma and the Effect of Some Plant Extract on their Survival

¹Olubode T. P., ²Agboola T.T., ¹Adaramola K.A., ¹Tairu H.M., ¹Oladeji, I.

¹Department of Science Laboratory Technology; ¹Faculty of Applied Sciences, ²Department of Agriculture and Bioenvironment Engineering; Faculty of Engineering, Oyo State College of Agriculture and Technology, Igboora, Oyo State, Nigeria.

Corresponding Author's E-mail: tolulope.olajesu@gmail.com

Abstract

Shawarma is a ready-to-eat snacks usually consumed by students and some middle aged adults. However, its chicken or meat sandwich could predispose it to bacterial contamination. Hence, this study determined the risk factor associated with bacteria isolated from Shawarma and the effect of some plants extract on their survival. Ninety-three bacteria were isolated from Shawarma purchased from different locations in Oyo state Nigeria. Bacteria were isolated from the frozen chicken with spread plate method and were tested for virulence and susceptibility to different plants extract (nutmeg, curry and scent leaves) while sensory evaluation was carried out on shawarma produced and spiced with nutmeg and curry leaves. The result showed that the shawarma was contaminated with *Escherichia coli*, *Klebsiella pneumoniae*, *Salmonella enterica*, *Staphylococcus aureus* and *Pseudomonas aeruginosa* with *Escherichia coli* having the highest percentage occurrence of 24% followed by *Staphylococcus aureus* (22%) while the least were *Klebsiella pneumoniae* (16%) and *Pseudomonas aeruginosa* (16%). *Staphylococcus aureus* and *Salmonella enterica* produced the highest DNase and Protease (100%), while *Pseudomonas aeruginosa* produced gelatinase (25%) as the least occurring virulent factor. Curry leaves extract greatly inhibited the growth of *Salmonella enterica* (45.0 mm) followed by Nutmeg which inhibited the growth of *Klebsiella pneumoniae* (43.0 mm) while Scent leaf least inhibited the growth of *Klebsiella pneumoniae* (40.0 mm). Nutmeg and curry leaves spiced shawarma taste, flavour, texture and overall acceptability were liked very much while the colour was extremely liked. It should therefore be possible to produce an acceptable and safe shawarma-sandwich for human consumption.

Keywords: Shawarma; virulent; contaminated; growth; acceptability

Introduction

Shawarma is a fast food commonly consumed as snacks across the Middle East, Europe, Caucasus and North-Africa, but fast gaining recognition in West-Africa especially in Nigeria and Ghana where it is sold in popular fast food centres (Nimri *et al.*, 2014). It is one of the most ready-to-eat sandwiches sold in fast food restaurants in Nigeria. Its consumption is common among students and families who go on outing as refreshment. It is a wrap of shredded meat containing beef or chicken prepared by stacking strips of fat and pieces of seasoned meat alternately, on a rotating vertical skewer. The meat is roasted from the outside, while most of the inside remains rare. Shavings are cut off the block of meat for serving, and the remaining block of meat is kept heated on the rotating skewer (Nimri *et al.*, 2014). Reportedly, meats have been associated with bacteria that cause food intoxication and infection and in most countries; the most common food borne illness is Staphylococcal food intoxication (Talaro and Talaro, 1996).

Staphylococcus spp. and enterotoxigenic *Escherichia coli* strains have been isolated from foods implicated in illnesses (Adesiyun, 1995) while in Nigeria, a number of foods have been reported to have high incidence of bacteria (Adesiyun, 1995; Okonko *et al.*, 2008) particularly, *Escherichia coli* 0157: H7, *Listeria monocytogenes*, *Campylobacter jejuni*, *Clostridium perfringens*, *Salmonella* spp. and *Staphylococcus aureus* which accounts for approximately 3.3- 12.3 million cases of food borne illnesses and a record of 3, 900 deaths each year (Talaro and Talaro, 1996; Akindele and Ibrahim, 2016). The detection of these bacterial pathogens in foods calls for investigation of shawarma sold in some restaurants and fast foods in Oyo town for bacteriological quality and probably proffers solution for their control and survival.

Methodology

Collection of samples

Shawarma was at different locations in Oyo town; Kabar foods Danzaria, Ace supermarket,



Planet 7 and MTC foods. Shawarma was purchased from different fast food restaurants in Oyo town (Kabar foods Danzaria, Aces supermarket, Planet 7 and MTC foods) and was transferred directly to Oyo State College of Agriculture and Technology Research Laboratory for further analysis. 1 gram of each ground Shawarma samples were serially diluted with 9 ml of sterile peptone water. 1 ml of the diluent was inoculated on sterile Nutrient Agar and MacConkey Agar, using pour plate method. Inoculated plates were incubated at 35°C for 24 hrs. Colonies were sub-cultured to get pure culture.

Phenotypic Identification of Bacterial Isolates

Isolates were identified using biochemical test such as Gram staining, catalase Oxidase, endospore formation test, indole, motility test, Voges Proskauer, citrate, coagulase and Bergey's manual of bacteriological identification was used to identify the isolates.

Determination of the Virulent Properties of the Isolates

The phenotypic virulent properties of the isolates from Shawarma were determined through coagulase, haemolysis, protease, DNase and gelatinase tests.

Gelatinase Activity

Nutrient agar was prepared according to the manufacturer's specification and gelatin pellets was added to it in equal amounts. The medium was homogenized and sterilized at 121°C for 15 minutes, it was cooled, poured into petri dishes and left to solidify. The test isolates were streaked on the agar and incubated at 37°C for 24 hours. Colonial growth on plates, were flooded with ammonium sulphate. A zone of clearance around the bacterial growth was interpreted as positive result (Smith and Goodner, 1958).

Proteolytic Activity

The skimmed milk agar was used for this test. It was prepared by adding 1% (w/v) skimmed milk to the appropriate agar (Harrigan and McCance, 1966). The media was sterilized by autoclaving at 110°C for 10 minutes in a water bath. It was dispensed after cooling into sterile Petri- dishes and then left to solidify. Plates were inoculated with the test isolates. Un-inoculated plates served as control. At the end of the incubation, a clear zone around the line

of streaking indicated casein hydrolysis due to the activity of the protease enzyme.

DNase Test

Dnase agar was used for this test. It was weighed, homogenized and sterilized at 121°C for 15 minutes, it was cooled and poured into petri dishes and then left to solidify. Spot inoculation was done on the agar with the test isolates and incubated at 37°C for 4 days. After incubation, 1mol/l of HCl was poured on the agar. A zone of clearance around the bacterial growth was interpreted as positive result (Deighton *et al.*, 1988).

Haemolysin Production

Blood agar was prepared by weighing nutrient agar, homogenized and then sterilized at 121°C for 15 minutes, it was cooled a little and sheep blood was added, mixed thoroughly by shaking, poured into petri dishes and allowed to solidify. A colony of each of the bacterial isolates were sub-cultured onto the freshly prepared blood agar plates and incubated at 37°C for 24 hours and the colonies were examined for haemolytic activity. The haemolytic activities of the isolates were identified by the presence of diffuse (alpha haemolysis) or clear (beta haemolysis) halos around the colonies (Akinjogunla *et al.*, 2014)

Extraction of Selected Plants

Ethanol extract was obtained by dissolving ten grams (10 gm) of each dried selected plant (Scent leaf, Curry leaf and Nutmeg) powder into 100 ml of ethanol and distilled water (8:2 w/v) it was cover with filter paper and kept for 24 h with continuous shaking. It was filtered and the filtrate was concentrated as extract of corresponding plants.

Determination of Antimicrobial Activity

A modified method of Manandhar *et al.* (2019) was used to determine the antibacterial activity of the ethanol extracts of selected plants (scent leaf, curry leaf and nutmeg) using agar well diffusion method. The test isolates were standardized with 0.5 McFarland Standard. Sterile Nutrient agar plates were inoculated with each standard isolate used to bore well into the inoculated agar and 4µl of the concentration (100, 150 and 200 mg/l) of each extract was introduced into the well. Plates were left for sometimes in order for the extract to diffuse into medium. Plates were incubated at 35°C for 24 hrs. The zone of clearance around the test bacteria was measured and



recorded as zone of inhibition of the bacteria isolates by each plant extract.

Sensory Evaluation of Shawarma

Sensory analysis of the milk samples was carried out by twenty-member panel of Judges consisting students of the Oyo State College of Agriculture and Technology (OYSCATECH), Igboora, who were familiar with the product. The organoleptic parameters used were colour appearance and odour. The ratings were presented on 9-point Hedonic scale ranging from 1= liked extremely to 9 = dislike extremely.

Results

This study revealed that Shawarma samples purchased from four locations in Oyo town were contaminated with bacteria, but the bacterial load of samples obtained from some locations were higher than others (table 1) to the extent that it may pose a threat to the health of regular consumers. The total coliform count in Shawarma from Kabba foods Danzaria (KDS) and Planets were higher (8.0 and 6.0×10^5 cfu/g) than that of MTCS (4.0×10^5 cfu/g) foods and Ace supermarket (4.0×10^5 cfu/g) while total aerobic bacterial counts were very high only in Ace Shawarma (7.0×10^5 cfu/g). Table 2 showed that five genera of bacteria were isolated from these samples which were *Salmonella enterica*, *Escherichia coli*, and *Pseudomonas aeruginosa* *Staphylococcus aureus* and *Klebsiella pneumoniae*. The percentage occurrence of the bacterial isolates recovered from Shawarma as shown in table 3 revealed that *Escherichia coli* (24%) prevailed over *Staphylococcus aureus* and *Salmonella enterica* (22%) while *Klebsiella pneumoniae* (16%) and *Pseudomonas aeruginosa* (16%) were the least occurring bacteria in the Shawarma. The virulent properties exhibited by bacteria are a measure of their degree of

pathogenicity while pathogenicity, is the ability of a pathogen to cause disease(s) in their host. The virulence factors profile of bacterial isolates from shawarma were studied (table 4-6) and all the isolates were haemolytic; an indication of the phenotypic expression of haemolysin which is a virulent factor produced by some bacterial pathogens. In this research, *E. coli* had the highest percentage (82.6%) haemolysis. Other virulent factors phenotypically expressed by these bacteria were DNase and gelatinase. *Staphylococcus aureus* produced the highest percentage DNase (100%) and gelatinase (80%)

The zone of inhibition of bacterial isolates from Shawarma by three plants extracts; Nutmeg, Curry leaf and Scent leaf is shown in table 7. The bacterial pathogens were susceptible to higher concentration (200 and 250 mg) of nutmeg and curry leaf extracts an implication that the activity of any plant is directly proportional to its concentration. However, only *Klebsiella pneumoniae* growth was inhibited at all concentration of the scent leaf extract with zone of inhibition ranging from 10-40 mm while *E. coli* was susceptible (25-35 mm) to scent leaf extract, but at higher concentrations (200-250 mg/l), In this study, *E. coli* was resistant to all the concentration of nutmeg extract but susceptible to curry leaf extract (15-30 mm), while *P. aeruginosa* was more susceptible to two of the spices (Nutmeg and curry leaf).

The sensory evaluation of shawarma spiced with nutmeg as shown in table 8, were all extremely acceptable in terms of colour (1.2), taste (1.5), flavour (1.2) and overall acceptability (1.0) by the panellists while that to which curry leaf was incorporated were extremely acceptable in colour (1.6), flavour (1.8) and texture (1.8).

Table 1: Mean bacterial load of Sharwama from Oyo metropolis $\times 10^5$ cfu/g

Sample code	Total aerobic count	Total coliform count
KDS	1.2	8.0
ASS	7.0	3.0
P7S	1.5	6.0
MTCS	1.5	4.0

Keys; KDS- Kabar foods Danzaria Sharwama, ASS-Ace supermarket Shawarma, P7S-Planet Sharwama, MTCS foods Sharwama



Table 2: Biochemical Test for Identification of Isolates from Shawarma

Isolates code	Indole	Motility	Methyl red	Voges Proskauer	H ₂ S	Formate	Citrate	Catalase	Oxidase	coagulase	Gram's Reaction	sucrose	Glucose	Lactose	Fructose	maltose	Galactose	Probable Bacteria
KDS231, KDS233, KDS212, KDS213, KDS221	+	-	+	+	+	+	+	+	-	-	+	+	+	-	+	-	-	<i>Pseudomonas aeruginosa</i>
KDS111, KDS112, KDS313, KDS223, ASS213, ASS221, ASS223, P7S322, P7S333, P7S323, P7S213, MTCS112, MTCS212, MTCS213, MTCS322	-	-	-	+	-	-	+	-	-	-	+	+	+	V	+	v		<i>Klebsiella pneumoniae</i>
KDS32, KDS322, KDS221, KDS121, KDS123, ASS13, ASS11, ASS23, ASS22, P7S231, P7S33, P7S321P7S322, P7S323, MTCS21, MTCS22, MTCS23, MTC	+	+	+	-	-	+	+	-	-	-	+	+	+	+	-	-	+	<i>Escherichia coli</i>
KDS32, KDS322, KDS221, KDS121, KDS123, ASS13, ASS11, ASS23, ASS22, P7S231, P7S33, P7S321P7S322, P7S323, MTCS21, MTCS22, MTCS23, MTC	-	+	+	+	+	+	+	+	+	+	-	-	+	+	-	+	-	<i>Salmonella enterica</i>
KDS223, KDS333, KDS311, KDS323, KDS211, KDS331, KDS131, KDS232 ASS21, ASS31, ASS33, P7S311, P7S2, P7S332, MTCS32, MTCS223, MTCS113, MTCS33, MTC	-	-	-	+	-	-	+	+	-	+	+	+	+	-	+	+	+	<i>Staphylococcus aureus</i>

Keys: KDS-Kaba food danzaria, ASS-Ace supermarket sharwama, P7S-Planet7 sharwama, MTC-sharwama, V-variable



Table 3: Percentage occurrence of bacterial isolates from Shawarma

Isolates (%)	No. of samples	Percentage
<i>Klebsiella pneumoniae</i>	15	16
<i>Escherichia coli</i>	23	24
<i>Salmonella enterica</i>	20	22
<i>Pseudomonas aeruginosa</i>	15	16
<i>Staphylococcus aureus</i>	20	22

Table 4: Percentage occurrence of Haemolytic Isolates from Sharwama (%)

Isolates	Frequency of haemolysis	Selected sample location (%)			
	Producers	KDS	ASS	P7S	
MTCS					
<i>Klebsiella pneumoniae</i> n=15	10(66.7)	4(26.7)	1(6.7)	2(13.3)	3(20.0)
<i>Escherichia coli</i> n=23	19(82.6)	6(26.1)	3(13.0)	6(26.1)	4(17.4)
<i>Salmonella enterica</i> n=20	16(80.0)	4(20.0)	3(15.0)	5(25.0)	4(20.0)
<i>Pseudomonas aeruginosa</i> n=15	12(80.0)	3(20.0)	0	4(26.6)	
<i>Staphylococcus aureus</i> n=20	15(75.0)	4(20.0)	0	5(25.0)	6(30.0)
Total=93.0	72(73.1)	2(21.3)	7(7.5)	22(22.4)	22(22.5)

Table 5: Percentage Occurrence of DNase Producing Isolates from Shawarma (%)

Isolates	Frequency of DNase	Selected sample location (%)			
	Producers	KDS	ASS	P7S	MTCS
<i>Klebsiella pneumoniae</i> n=15	14(93.3)	6(40.0)	0	2(13.3)	6(40.0)
<i>Escherichia coli</i> n=23	10(43.5)	2(8.7)	1(4.4)	3(13.0)	4(17.4)
<i>Salmonella enterica</i> n=20	14(70.0)		5(25.0)	2(10.0)	5(25.0)
<i>Pseudomonas aeruginosa</i> n=15	12(80.0)	8(40.0)	3(15.0)	3(15.0)	6(30.0)
<i>Staphylococcus aureus</i> n=20	20(100.0)	6(40.0)	0	2(13.3)	6(40.0)
Total=93.0	70(71.1)	25(25.5)	8(8.6)	12(12.9)	5(26.9)

Table 6: Percentage Occurrence of Gelatinase Producing Isolates from Shawarma (%)

Isolates	Frequency of gelatinase	Selected sample location			
	Producers	KDS	ASS	P7S	MTCS
<i>Klebsiella pneumoniae</i> (n=15)	12(80.0)	5(33.3)	2(13.3)	3(20.0)	5(33.3)
<i>Escherichia coli</i> (n=23)	12(52.6)	4(17.3)	3(13.0)	2(8.7)	3(13.0)
<i>Salmonella enterica</i> (n=20)	12(80.0)	5(25.0)	3(15.0)	2(10.0)	2(10.0)
<i>Pseudomonas aeruginosa</i> (n=15)	5(25.0)	4(26.7)	3(20.0)	2(13.3)	6(40.0)
<i>Staphylococcus aureus</i> n=20	12(80.0)	3(15.0)	1(5.0)	2(10.0)	1(5.0)
Total=93.0	51(51.9)	21(21.4)	12(12.2)	11(11.2)	17(17.4)

Table 7: Inhibition zones of Bacteria from Shawarma by selected Plant Extract (mm)

Plant extract	Plant extract Concentration (mg)	<i>Klebsiella pneumoniae</i>	<i>Escherichia coli</i>	<i>Salmonella enterica</i>	<i>Pseudomonas aeruginosa</i>	<i>Staphylococcus aureus</i>
Nutmeg	100	18	-	18	10	10
	150	28	-	15	15	18
	200	33	-	35	23	23
	250	43	-	40	30	38
Curry leaf	100	-	15	15	15	10
	150	-	18	20	20	20
	200	-	28	25	25	30



	250	-	30	45	30	38
Scent leaf	100	10	-	-	-	-
	150	20	-	-	-	-
	200	25	25	-	-	-
	250	40	35	-	-	-

- means no inhibition

Table 8: Sensory Evaluation of Shawarma Spiced with Nutmeg and Curry Leaf Powder

Sample	Colour	Taste	Flavour	Texture	Overall acceptability
Shawarma+nutmeg	1.2±0.0	1.5±0.	1.2±0.0	2.1±0.0	1.0±0.0
Shawarma+curry leaf	1.6±0.0	2.1±0.0	1.8±0.0	1.8±0.0	2.0±0.0

Discussion

The established food safety know-how among ready-to-eat food and their vendors regarding food contamination, types and symptoms of food diseases was significant since several pathogenic microorganisms had also been isolated from many streets vended foods (Omemu *et al.*, 2005). Adequate temperature in cooking and storage of foods is important to minimize the growth of bacteria and the food that cannot maintain within the safety temperature zone may act as incubator for pathogenic bacteria whether the food is raw, partially cooked or fully done (Abdalla *et al.*, 2008; Bintsis, 2017).

In this study, a higher total coliform bacterial count was observed for all Shawarma samples from all the food locations sampled in Oyo than acceptable limit (<100 cfu/g) recommended by International Food Safety and Quality Network (2018). This implies that the preparation of this ready to eat food was either not made under a hygienic condition or the raw materials as well as the containers used were not properly processed to have been free from contaminants. The presence of some Bacteria of public health importance in the Shawarma agrees with the report of Oluwafemi and Semisaye (2005) as well as Okonko *et al.* (2009) where similar bacteria were isolated from sausages, hamburgers and sea foods. This depicts a deplorable state of poor hygiene and sanitary practices employed by the processors at all levels of production process as well as cross contamination of raw materials and packaging of this food. *E. coli* was the most predominant bacteria isolated from shawarma in this study which is similar to the work of Adebayo-Tayo *et al.* (2012) and Igbinsola *et al.* (2020) where the most occurring bacteria in their ready to eat food was reported as *E. coli*. This may be due to the ability of this bacterium

to survive under an extreme environmental condition when given off from the intestine of animals and human. Presently, it is the indicator of faecal contamination of any food materials. Some of these bacteria could be potentially pathogenic, some strains of *E. coli* can cause gastroenteritis and diarrhoea and it's a major cause of travellers and childhood diarrhoea. *Klebsiella pneumoniae* is considered opportunistic pathogens but produce significant endotoxin that can mediate fatal infection. The prevalence of *E. coli* in the shawarma purchased from different locations in Oyo is an indication of faecal contamination of the product and may have resulted from water used during preparation and the meat used to prepare the sauce.

Most of the bacteria possess some pathogenicity properties such as haemolysin, DNase and gelatinase that may pose risks to human health. All the bacteria were able to produce haemolysin but highest percentage of *E. coli*, *Salmonella enterica* and *Pseudomonas aeruginosa* produced haemolysin as a virulent factor that lyses blood cells. However, all the bacterial isolates produced DNase and gelatinase and are therefore said to be potential pathogens because, the ability of pathogens to cause diseases in the host lies partly on the production of virulent factors which could either act singly or in combination to cause diseases depending on the nature of the host defence mechanisms (Balioux and Dorp, 2017). In this study, all *Staphylococcus aureus* produced Dnase in contrast with other isolates, where some produced DNase. David *et al.* (2010) reported that some bacteria like *Staphylococcus* species could produce DNase which may be responsible for tissue degradation and spreading of an infection caused by these bacterial species. Hence, these bacteria could



cause health related food borne diseases where they are consumed along with shawarma.

Interestingly, facts have been documented on the various antimicrobial properties of various plants extracts used as spices for foods (Gull *et al.*, 2012). These plants also have unique flavour and aroma from compounds known as phyto-chemicals (Hossain *et al.*, 2013). These phyto-constituents are generally present in medicinal plants and are good source of antioxidants and antimicrobials. *Klebsiella pneumoniae* was the only bacterium inhibited at all concentrations of scent leaf ethanol extract while *E. coli* was susceptible, but at higher concentrations, this is similar to the research of Ubafe and Ejale (2018), where *K. pneumoniae* and *E. coli* were susceptible to scent leaf ethanol extract but disagree with that of Oladele and Ologundudu (2022) where both bacteria were resistant to the extract.

The susceptibility of *E. coli* to all concentrations of curry leaf extract and its resistance to nutmeg ethanol extract disagrees with the work of Anibijuwon and Omojasola *et al.* (2013) where *E. coli* growth was inhibited by ethanol extract of the two spices but at higher concentration. This may be due to strain diversity, since strains of the same species do not have absolutely the same genetic makeup. However, this work corroborates with the research of Ibrahim *et al.* (2013) where *E. coli* was resistant to Nutmeg.

The Scent leaf extract used in this research only inhibited the growth of *Klebsiella pneumoniae* and *E. coli*. *E. coli* was susceptible to the ethanol extract of scent leaf as observed and reported by Amjad (2013) but *Staphylococcus aureus* was resistant to the extract in this study. The acceptability of Shawarma spiced with nutmeg and curry leaf powder by the panellists implies that nutmeg and curry leaf may have certain phyto-constituent(s) that could improve the organoleptic acceptability of food to which it is added.

Conclusion

This study has shown that ready to eat food like shawarma contain potentially pathogenic bacteria capable of causing diseases in consumers since most of these bacteria have been reported to have caused various food borne illnesses and infections. The presence of these pathogens in shawarma samples could be attributed to poor and unhygienic handling,

storage, ingredients and processing steps used for its preparation. Hence proper hygiene should be adequately practiced and maintained during shawarma production and possibly spices used in this study could also be incorporated into the snacks in acceptable quantity as part of the control measure against the presence of these bacteria in shawarma.

References

- Abdalla A., Kleen S. and Mader K.A. (2008). New self-emulsifying drug delivery system (SEDDS) for poorly soluble drugs: characterization, dissolution, *in vitro*-digestion and incorporation into solid pellets. *Eur. J. Pharm. Sci.* 35 (5): 457-64.
- Adebayo-Tayo B.C., Odu N.N., Micheal M. U. and Okonko I. O. (2012). Multidrug resistant (MDR) organisms isolated from sea foods in Uyo, South-Southern region of Nigeria. *Nature and Science* 10 (3): 61-70.
- Adesiyun, A. A. (1995). Bacteriological Quality of Some Trinidad Ready-to-Eat Consumer Food or Drink and Possible Health Risk to Consumer. *Journal Applied Science Environment* 14: 29-34.
- Akindele P.O. and Ibrahim K.A. (2016). Microbiological analysis of ready to eat foods obtained from Bukatarian within the Ekiti State University and Environment, Ado Ekiti, Nigerian. *Journal of Advances in Microbiology* 1(2): 1-8.
- Akinjogunla O. J., Ajayi A. O., and Ekeh N. (2014). Virulence factors and antibiotics resistant *Staphylococcus* spp. from the anterior nares of apparently healthy undergraduate students in Uyo. *Am. J. Res. Commun.* 2(11): 158-180.
- Amjad K. (2013). Antimicrobial activity of ethanolic extracts of *Ocimum brasicum* leaf from Saudi Arabia. *Biotechnology* 12: 61-64.
- Balioux F. and Dorp L.V. (2017). Q&A: What are pathogens and what have they done to and for us? *BMC Biol.* 15: 91.
- Bintsis T. (2017). Foodborne pathogens. *AIMS Microbiol.* 3(3): 529-563.



- David P.K., Cyrus N.K., Fred A.K., Alfred O., Moses S.O., Ann N., Moses L.J. and Florence C.N. (2010). Identification of *Staphylococcus aureus*: DNase and Mannitol salt agar improve the efficiency of the tube coagulase test. *Ann. Clin. Microbiol. Antimicrob.* 9:23.
- Deighton J.C., Flaklin W.J. and Spicer B.B. (1988). Species Identification, antibiotics sensitivity and slime production by coagulase-negative *Staphylococci* isolated from clinical specimens *Epidemiol. Infect.* 101 (1): 99-113.
- Gull I., Saeed M. and Shaukrat H. (2012). Inhibitory effect of *Allium sativum* and *Zingiber officinale* extracts on clinically important drug resistant pathogenic bacteria. *Ann. Clin. Microbiol. Antimicrob.* 11:8.
- Harrigan W.F. and McCance E.M. (1966). *Laboratory Methods in Microbiology*. Academic Press Cambridge 54: 970.
- Hossain M.A., Ahmed K., AL-Raqmi S., AL-Mijzi Z.H., Weli A.M. and Al-Riyami Q. Study of total phenol, flavonoids contents and phytochemical screening of various leaves crude extracts of locally grown *Thymus vulgaris*. *Asian Pac.J. Tro. Biomed.* 3(9):705-710.
- Ibrahim K.M., Naem R.K. and Abd-Sahib A.S. (2013). Antibacterial Activity of Nutmeg (*Myristica fragrans*) seeds extract against some pathogenic bacteria. *Journal of Al-Nahrain University*. 16 (2): 188-192.
- Igbinosa I. H., Beshiru A., Egharevba N.E. and Igbinosa E. O. (2020). Distribution of ready to eat foods in cafeterias and Retails foods in Benin City: Public health implication. *Journal of Community Medicine and Primary Health care* 32 (2): 80-94.
- Manandhar S, Luitel S. and Dahal R. K. (2019). *In vitro* antimicrobial activity of some medicinal plants against human pathogenic bacteria. *J. Trop.Med.* 1895340.
- Nimri L., Al-Dahab F.A. and Batchoun R. (2014). Foodborne bacterial pathogens recovered from contaminated shawarma meat in northern Jordan. *The Journal of Infection in Developing Countries* 8 (11): 1407-1414.
- Okonko L.O., Ogunjobi A.A, Fajobi E.A., Onaja B.A., Babalola E.T. and Adedeji A.O. (2008). Comparative Studies and different assessment journal of Ready-to-Eat (RTE) Frozen Sea Foods Processed in Ijola-Olopa Lagos State, Nigeria. *Journal African Biotechnology* 16: 2898 – 2901.
- Oladele I. S. and Ologundudu F. A. (2022). Antimicrobial and synergistic potential of *Occimum gratissimum* leaves and *Petiveria alliacea* bark against some selected microorganisms. *Annals of Environmental Science and Toxicology* 6(2): 41-46.
- Oluwafemi F. and Semisaye M. T. (2005). Extent of Microbial contamination of sausages sold in two Nigerian cities. Annual conference of general meeting Abeokuta Nigeria: Microbes society for Microbiology (MSM) University of Agriculture.
- Omemu A.M., Akpan I., Bankole M.O. and Teniola O. (2005). Hydrolysis of raw tuber starches by amylase of *Aspergillus niger* AMO7 isolated from the soil. *Afr. J. Botechnol.* 4(1): 19-25.
- Omojowo F. and Omojasola E. (2013). Antibiotics Resistance Pattern of Bacterial Pathogens isolated from poultry Manure used to fertilize fish ponds in New Bussa, Nigeria. *Albanan Journal of Agricultural Science* 12: 81-85.
- Smith H.L. and Goodner K. (1958). Detection of bacterial gelatinases by gelatin-agar plate methods *J. Bacteriol.* 76 (6): 662-665.
- Talaro, K. and Talaro A. (1996). *Foundations in Microbiology* McGraw Hill U.S.A. 2:840 – 841.
- Ubafie M.O. and Ejale A.U. (2018). Antimicrobial activity and quantitative analysis *Ocimum gratissimum* on some pathogenic bacteria. *Issues in Biological Sciences and Pharmaceutical Research* 6 (2): 17-22.
- Umana M.N., Mi X., Cao M. and Enquist B.J. (2017). The role of functional uniqueness and spatial aggregation in explaining ravity in trees. *Global Ecol. Bogeogr.* 7:1-10.