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Research Article

Prevalence and Antibiogram of *Salmonella enterica* Isolated from Seafood Sold in Rivers State, Nigeria

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ABSTRACT

Consumption of seafood contaminated with *Salmonella enterica* can lead to life threatening illnesses and its multidrug resistance profile is of public health concerns. This study was conducted to determine the prevalence and antibiogram of *Salmonella enterica* isolated from seafood sold in Rivers State, Nigeria. A total of 126 raw and parboiled samples of *Crassostrea gasar* (Oyster) (42), *Panaeus monodon* (Prawn) (42) and *Buccinum undatum* (Whelks) (42) were purchased from three (3) Local Government Area markets and subjected to bacteriological and biochemical analyses using standard conventional methods**.** Antibiotic susceptibility pattern was ascertained using Kirby-Bauer disc diffusion method. Total *Salmonella* count (TSC) for raw Oyster, Prawn and Whelks in Creek Road market were 3.2±0.7x10^2CFU/g; 3.2±0.5x10^2CFU/g and 4.7±0.2x10^2CFU/g respectively. While counts for parboiled samples were 3.0±0.9x10^2CFU/g; 1.8±0. x10^2CFU/g and 3.7±0.3x10^2CFU/g respectively. The TSC for raw Oyster, Prawn and Whelks in Kaa market were 2.9±0.7x10^2CFU/g; 2.2±0.9x10^2CFU/g and 3.6±0.2x10^2CFU/g and counts of parboiled samples were 2.3±0.4x10^2CFU/g; 1.4±0.2x10^2CFU/g and 2.8±0.1x10^2CFU/g respectively. TSC for raw Oyster, Prawn and Whelks from Bakana market were 2.7±0.7x10^2CFU/g; 1.6±0.2x10^2CFU/g and 3.1±0.5x10^2CFU/g while TSC in parboiled samples were 1.6±0.3x10^2CFU/g; 1.2±0.1x10^2CFU/g and 2.4±0.2x10^2CFU/g, respectively. Generally, there was a significant difference ($p \leq 0.05$) in the total *Salmonella* counts across the various markets from the seafoods. Forty (40) *Salmonella enterica* were isolated from the 126 seafood samples analyzed and Prawn (40%) had the highest prevalence. *Salmonella enterica* were resistant to Impenem/Cilastatin (97.5%) Augmentin (95%), Cefotaxime (92.5%) and Nitrofurantoin (90%) and sensitive to Ofloxacin (65%) and 100% of the isolates had MAR indices ≥0.2. The high prevalence and resistance rate observed in this study indicates the potential risk of transmission of *S. enterica* to humans through consumption of inadequately processed seafood, which can have serious implications for public health. It is essential that more effective control strategies be put in place to reduce the prevalence of *S. enterica* in seafoods sold in Rivers State.

Keywords: Markets, Seafoods, whelks, oysters, *Salmonella enteric*, parboiled, antibiogram, prevalence.

Introduction

The level of consumption of seafoods such as prawn, whelks, clams, mussels and oysters has increased over the years especially in developing countries because of its potential nutritional benefits (Heinitz *et al*., 2000). On the average humans now eat about 16.7 pounds of seafood each year as reported. Due to the high nutritional benefit, the public rarely consider the risk involved in eating seafood contaminated with *Salmonella enterica* which have been found to be associated with seafood **(**Hibbeln *et al*., 2007). This bacterium, *Salmonella enterica* has been known to cause infections ranging from gastroenteritis to chronic life-threatening infections of serious medical importance.

Salmonella is a rod-shaped, Gram-negative facultative anaerobe that belongs to the family Enterobacteriaceae (Bakowski *et al.*, 2008). *Salmonella enterica* are present as human and animal pathogens, *Salmonella* is a highly contagious bacterium that spreads primarily when animals and humans consume contaminated feed or water as well as seafoods (Silva *et al.,* 2011).

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Salmonella causes enteric fevers which spread mainly from person-to-person via the fecal-oral route and have no significant animal reservoirs. Asymptomatic human carriers may spread the disease ((Bakowski *et al.*, 2008). *Salmonella* infection remains a major public health concern worldwide, contributing to the economic burden of both industrialized and underdeveloped countries through the costs associated with surveillance, prevention and treatment of disease (Crump *et al.*, 2004).

Salmonellosis is the most common manifestation of *Salmonella enterica* infection worldwide, followed by bacteremia and enteric fever (Majowicz *et al.*, 2010). The resistance of these organisms to novel antibiotics such as Ciprofloxacin, Erythromycin, Gentamicin, Chloramphenicol, and some Trimethoprim-sulfamethoxazole, is alarming (Sobel and painter, 2005). These seafoods obtained these organisms from different sources such as their environment, their mode of feeding, how they are harvested, the manner in which they are prepared and served for consumption. Seafood including oysters, shrimps, prawn, oysters, crab, lobsters filter large volume of water and in the process, they accumulate pathogenic microorganisms such as *Salmonella enterica*, that are naturally present in the harvest waters leading to their high prevalence in these seafoods **(**Mozaffarian and Rimm 2006). Hence, this research was carried out to determine prevalence and antibiogram of *Salmonella enterica* isolated from seafoods sold in Rivers State.

Materials and Methods

Description of study Area

The study was carried out in markets of three different Local Government Areas in Rivers State. The Government Areas are; Port Harcourt Local Government Area (PHALGA), Khana Local Government Area, and Degema Local Government Area. While the markets from which seafood samples were collected are Creek Road Market, Kaa market and Bakana market respectively.

Collection of Samples

A total of 126 raw and parboiled seafood samples of Whelks (*Buccinum undatum*), Oyster (*Crassostrea gasar*) and Prawn (*Penaeus monodon*), identified by Professor G.C. Akani in the Department of Animal and Environmental Biology, Rivers State University, were purchased and put in sterile bags from three (3) markets and put in ice-chest, transported aseptically to the Department of Microbiology Laboratory, RSU, Port Harcourt for bacteriological analysis.

Microbiological Analysis

Enumeration and Preservation of Pure Cultures of Bacteria

The enumeration of the total *Salmonella* count was carried out using *Salmonella-Shigella* agar. The stock analytical unit was done by weighing ten (10) grams of the edible part of the raw and parboiled seafoods samples and homogenizing in 90ml of sterile normal saline for enumeration, isolation and identification. Ten-fold serial dilution was performed subsequently by pipetting 1ml of the samples into 9ml of sterile normal saline. About 0.1ml of the appropriate dilutions (10^1) was inoculated in duplicates onto already prepared sterile plates of *Salmonella-Shigella* agar using the spread plate technique and incubated at 37^{o}C for 24 hours after which the plates were counted and recorded. Discrete colonies were described and sub-cultured onto nutrient agar plates and incubated at 37^{o}C for 24 hours to obtain pure cultures (Taylor, 2008). The pure cultures were stored in 10% (v/v) glycerol suspension at -4^{o}C to prevent damage of the pure cultures during drying for further analysis.

Isolation and Identification of *Salmonella enterica*

Salmonella enterica were isolated based on their colonial/morphological characteristics such as the size, margin, surface, colour (black), elevation, texture and transparency and identification was carried out through conducting series of biochemical tests such as Oxidase, Catalase, Coagulase, Citrate Utilization, Methyl red, Indole, Voges Proskauer, sugar fermentation tests and specifically hydrogen sulphide production to confirm *Salmonella enterica* (Cheesbrough, 2005).

Antibiotic Susceptibility Technique

The Kirby Bauer disk diffusion method was used on sterile Mueller-Hinton agar to assess the antimicrobial susceptibility profiles of the isolates to conventional antibiotics. Standardization of the *Salmonella* isolates was conducted by adjusting to 0.5 McFarland turbidity standards (x10^8 cells).

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The swab was deepened into suspension and streaked over the surface of the agar plates, rotating the agar plate 60° to ensure appropriate distribution of the inoculum. The plates were air dried for 3–5 min. Standard antibiotics disk impregnated with Gentamicin (10µg), Ceftriaxone Sulbactam (45µg), Nalidixic acid (30µg), Cefexime (5µg), Ampiclox (10µg), Cefuroxime (300µg), Nitrofurantoin (300µg), Levofloxacin (5µg), Impenem/Cilastatin (10µg), Augmentin (30µg), Ofloxacin (5µg) and Cefotazime (25µg), were aseptically placed on the surface of the inoculated agar plate with sterile forceps. The disk was pressed down to make full contact with the surface of the agar. The plates were then incubated for 24 hours at 33 to 35ºC in an inverted position. The zones of inhibition were measured in millimeter (mm) and compared to (CLSI, 2017).

Determination of Multiple Antibiotic Resistance (MAR) index

According to Krumperman, (1985), multiple antibiotic resistance refers to bacterial isolates' resistance to three or more different antibiotics. Multiple antibiotic resistance (MAR) index was determined by using the formula MAR = a/b, where ‘’a’’ represent the number of antibiotics to which the test isolates depicted resistance and ‘’b’’ refers to the total number of antibiotics to which the test isolate has been tested for susceptibility.

Data Analysis

The data obtained was analyzed using analysis of variance (ANOVA) to test for significance and where differences occur Duncan multiple range test was used to separate the means using the Statistical Package for Social Science (SPSS) version 22 (Bewick *et al*., 2004)

Results

The results of the total *Salmonella* count (TSC) for raw Oyster, Prawn and Whelks in Creek Road Market, Kar Market and in Bakana Market are as shown in Table 1, Table 2, and Table 3 respectively. Generally, the study recorded significantly high population of *Salmonella enterica* in the seafood samples with significant difference ($p \leq 0.05$) across the various seafoods. In Creek Road market, the total *Salmonella* count (TSC $x10^2$ CFU/g) for raw Oyster, Prawn and Whelks is between 3.2±0.7; 3.2±0.5 and 4.7±0.2 respectively while in the parboiled samples is between 3.0±0.9; 1.8±0.3 and 3.7±0.3 $x10^2$ CFU/g respectively (Table 1). In Kaa market, the total *Salmonella* count (TSC) for raw Oyster, Prawn and Whelks is between 2.9±0.7; 2.2±0.9 and 3.6±0.2 $x10^2$ CFU/g but in the parboiled samples is 2.3±0.4; 1.4±0.2 and 2.8±0.1 $x10^2$ CFU/g respectively (Table 2). Bakana market indicated that the total *Salmonella* count (TSC) for raw Oyster, Prawn and Whelks is 2.7±0.7; 1.6±0.2 and 3.1±0.5 $x10^2$ CFU/g while in parboiled samples is 1.6±0.3; 1.2±0.1 and 2.4±0.2 $x10^2$ CFU/g, respectively (Table 3).

Table 1: *Salmonella* counts of Raw and Parboiled *Crassostrea gasar* (Oyster), *Panaeus monodon* (Prawn) and *Buccinum undatum* (Whelks) Sampled from Creek Road Market

Sampling Month	Oyster (×10^2 CFU/g)		Prawn (×10^2 CFU/g)		Whelks (×10^2 CFU/g)	
	Raw	Parboiled	Raw	Parboiled	Raw	Parboiled
June	3.8	3.5	2.9	1.6	4.8	3.8
July	2.4	1.6	3.5	1.8	4.5	3.9
August	2.7	2.4	3.8	1.6	4.9	3.3
September	2.6	2.8	3.7	1.9	4.6	3.4
October	3.6	3.8	2.5	1.8	4.6	3.9
November	3.8	3.9	2.8	2.3	4.9	3.8
Mean±SD	3.2±0.7	3.0±0.9	3.2±0.5	1.8±0.3	4.7±0.2	3.7±0.3

***T-Test shows there was a significant difference ($p \leq 0.05$) in the different Seafoods**

Table 2: *Salmonella* counts of Raw and Parboiled *Crassostrea gasar* (Oyster), *Panaeus monodon* (Prawn) and *Buccinum undatum* (Whelks) Sampled from Kaa Market

Sampling Month	Oyster (×10^2 CFU/g)		Prawn (×10^2 CFU/g)		Whelks (×10^2 CFU/g)	
	Raw	Parboiled	Raw	Parboiled	Raw	Parboiled
June	3.6	2.4	1.7	1.3	3.8	2.9
July	2.1	1.5	1.5	1.4	3.9	2.7
August	2.4	2.5	3.1	1.2	3.3	2.8
September	2.3	2.3	3.4	1.4	3.4	2.9
October	3.2	2.5	1.5	1.5	3.5	2.7
November	3.6	2.6	1.7	1.8	3.7	2.6
Mean±SD	2.9±0.7	2.3±0.4	2.2±0.9	1.4±0.2	3.6±0.2	2.8±0.1

***T-Test shows there was a significant difference (p≤0.05) in the different Seafoods**

Table 3: *Salmonella* counts of Raw and Parboiled *Crassostrea gasar* (Oyster), *Panaeus monodon* (Prawn) and *Buccinum undatum* (Whelks) Sampled from Bakana

Sampling Month	Oyster (×10^2 CFU/g)		Prawn (×10^2 CFU/g)		Whelks (×10^2 CFU/g)	
	Raw	Parboiled	Raw	Parboiled	Raw	Parboiled
June	3.1	1.4	1.4	1.1	3.4	2.5
July	2.0	1.2	1.6	1.2	3.6	2.6
August	2.1	1.9	1.8	1.3	3.0	2.2
September	2.2	1.7	1.8	1.1	3.1	2.5
October	3.0	1.3	1.2	1.0	3.1	2.4
November	3.6	1.8	1.5	1.3	2.2	2.1
Mean±SD	2.7±0.7	1.6±0.3	1.6±0.2	1.2±0.1	3.1±0.5	2.4±0.2

***T-Test shows there was a significant difference (p≤0.05) in the different Seafoods**

The prevalence of *Salmonella enterica* in raw and parboiled seafood samples from Creek Road Market, Kar Market and Bakana Market are as shown in Figure 1. Specifically, the prevalence of *Salmonella enterica* in raw Whelks, Prawn and Oysters samples were 37.5%, 40% and 33.33% respectively and were higher than the parboiled samples.

The results of the susceptibility pattern of *Salmonella enterica* in raw and parboiled samples of Oyster, Prawn and whelks are as shown in Table 4. indicated a greater number of the *Salmonella enterica* isolates were susceptible to Ofloxacin (66.7% and 33.3%) respectively and were highly resistant to Impenem/Cilastatin (100% and 100%); Cefotaxime (83.3%, 100%); Amoxicillin clavulanate (83.3% and 100%); Nitrofurantoin (83.3% and 100%); Cefuroxime (83.3% and 100%); Cefexime (83.3% and 66.7%); Ampiclox (77.8% and 66.7%) and Levofloxacin (66.7% and 66.7%), respectively.

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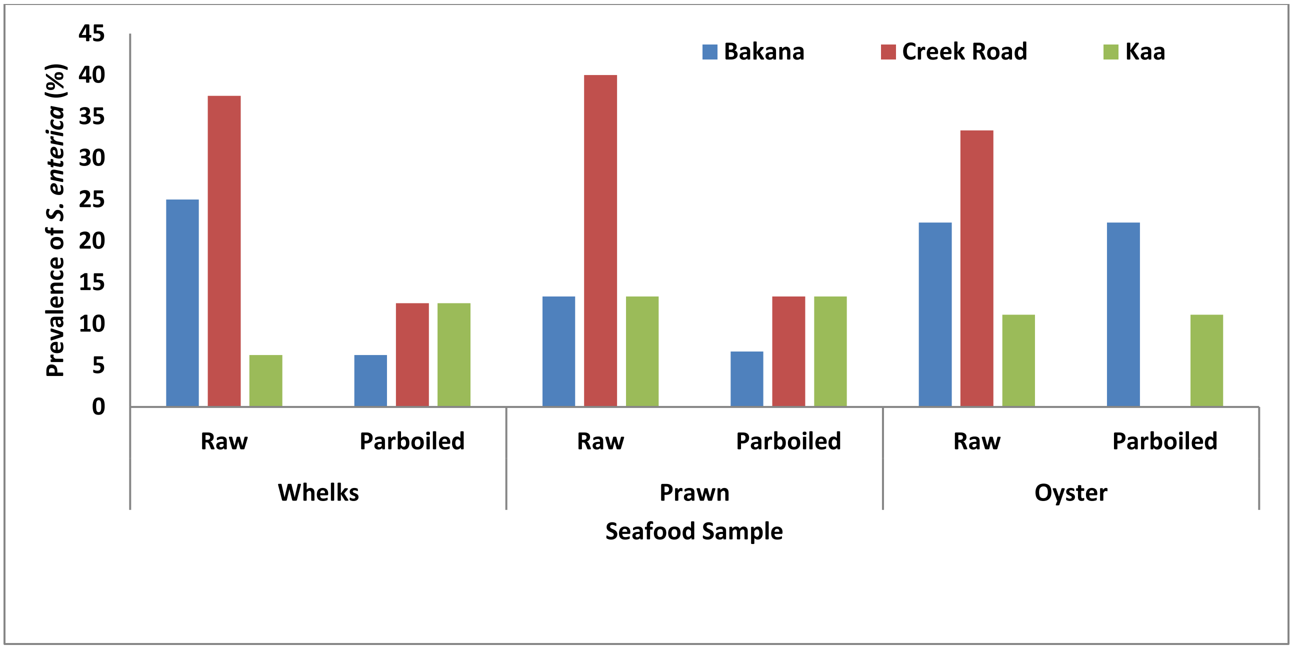

Fig. 1: Prevalence of *Salmonella enterica* in both raw and parboiled seafood from the different markets

Table 4: Susceptibility Pattern of *Salmonella enterica* (n=11) isolated from *Crassostrea gasar* (Oyster)

Antibiotics	Conc. (µg)	Raw (n=8)			Parboiled (n=3)		
		R	I	S	R	I	S
Ceftriaxone Sulbactam	45	4(66.7)	0(0.00)	2(33.3)	2(66.7)	0(0.00)	1(33.3)
Nalidixic acid	30	5(83.3)	1(16.7)	0(0.00)	3(100)	0(0.00)	0(0.00)
Cefexime	5	5(83.3)	0(0.00)	1(16.7)	2(66.7)	0(0.00)	1(33.3)
Ampiclox	10	7(77.8)	0(0.00)	2(22.2)	2(66.7)	1(33.3)	0(0.00)
Cefuroxime	30	5(83.3)	0(0.00)	1(16.7)	3(100)	0(0.00)	0(0.00)
Nitrofurantoin	300	5(83.3)	0(0.00)	1(16.7)	3(100)	0(0.00)	0(0.00)
Levofloxacin	5	4(66.7)	1(16.7)	1(16.7)	2(66.7)	1(33.3)	0(0.00)
Impenem/Cilastatin	10	8(100)	0(0.00)	0(0.00)	3(100)	0(0.00)	0(0.00)
Amoxicillin clavulanate	30	5(83.3)	0(0.00)	1(16.7)	3(100)	0(0.00)	0(0.00)
Gentamicin	10	3(50)	0(0.00)	3(50)	2(66.7)	0(0.00)	1(33.3)
Ofloxacin	5	2(33.3)	0(0.00)	4(66.7)	2(66.7)	0(0.00)	1(33.3)
Cefotaxime	25	5(83.3)	1(16.7)	0(0.00)	3(100)	0(0.00)	0(0.00)

Key: R-Resistant; I-Intermediate; S-Susceptible

The results of the susceptibility pattern of *Salmonella enterica* in raw and parboiled samples of Prawn and whelks are as shown in Table 5, and Table 6 respectively. *Salmonella enterica* from raw and parboiled Prawn showed varying susceptibility pattern. The isolates were susceptible to Ofloxacin (60% and 80%), and were resistant to Impenem/Cilastatin (90% and 100%); Cefotaxime (90%, 100%); Amoxicillin clavulanate (100% and 100%); Nitrofurantoin (90% and 80%); Cefuroxime (100% and 80%); Cefexime (80% and 80%); Ampiclox (90% and 80%) and Levofloxacin (80% and 80%), respectively (Table 5). while in *Salmonella enterica* isolates from raw and parboiled Whelks were susceptible to Ofloxacin (75% and 50%), respectively and resistant to Nitrofurantoin (91.7% and 100%); Cefuroxime (83.3% and 75%); Cefexime (83.3% and 75%); Ampiclox (83.3% and 100%), Levofloxacin (83.3% and 100%), Impenem/Cilastatin (100% and 100%); Cefotaxime (91.7%, 100%) and Amoxicillin clavulanate (100% and 100%) respectively (Table 6).

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Table 5: Susceptibility Pattern of *Salmonella enterica* (n=15) isolated from *Panaeus monodon* (Prawn)

Antibiotics	Conc. (µg)	Raw (n=10)			Parboiled (n=5)		
		R	I	S	R	I	S
Ceftriaxone Sulbactam	45	8(80)	0(0.00)	2(20)	4(80)	0(0.00)	1(20)
Nalidixic acid	30	10(100)	0(0.00)	0(0.00)	5(100)	0(0.00)	0(0.00)
Cefexime	5	8(80)	0(0.00)	2(20)	4(80)	1(20)	0(0.00)
Ampiclox	10	9(90)	1(10)	0(0.00)	4(80)	0(0.00)	1(20)
Cefuroxime	30	10(100)	0(0.00)	0(0.00)	4(80)	0(0.00)	1(20)
Nitrofurantoin	300	9(90)	1(10)	0(0.00)	4(80)	0(0.00)	1(20)
Levofloxacin	5	8(80)	0(0.00)	2(20)	4(80)	0(0.00)	1(20)
Impenem/Cilastatin	10	9(90)	0(0.00)	1(10)	5(100)	0(0.00)	0(0.00)
Amoxicillin clavulanate	30	10(100)	0(0.00)	0(0.00)	5(100)	0(0.00)	0(0.00)
Gentamicin	10	7(70)	1(10)	2(20)	4(80)	0(0.00)	1(20)
Ofloxacin	5	4(40)	0(0.00)	6(60)	1(20)	0(0.00)	4(80)
Cefotaxime	25	9(90)	1(10)	0(0.00)	5(100)	0(0.00)	0(0.00)

Key: R-Resistant; I-Intermediate; S-Susceptible

Table 6: Susceptibility Pattern of *Salmonella enterica* (n=16) isolated from *Buccinum undatum* (Whelks)

Antibiotics	Conc. (µg)	Raw (n=12)			Parboiled (n=4)		
		R	I	S	R	I	S
Ceftriaxone Sulbactam	45	9(75)	1(8.3)	2(16.7)	3(75)	1(25)	0(0.00)
Nalidixic acid	30	11(91.7)	1(8.3)	0(0.00)	3(75)	1(25)	0(0.00)
Cefexime	5	10(83.3)	1(8.3)	1(8.3)	3(75)	0(0.00)	1(25)
Ampiclox	10	10(83.3)	0(0.00)	2(16.7)	4(100)	0(0.00)	0(0.00)
Cefuroxime	30	10(83.3)	1(8.3)	1(8.3)	3(75)	1(25)	0(0.00)
Nitrofurantoin	300	11(91.7)	0(0.00)	1(8.3)	4(100)	0(0.00)	0(0.00)
Levofloxacin	5	10(83.3)	1(8.3)	1(8.3)	4(100)	0(0.00)	0(0.00)
Impenem/Cilastatin	10	12(100)	0(0.00)	0(0.00)	4(100)	0(0.00)	0(0.00)
Amoxicillin clavulanate	30	12(100)	0(0.00)	0(0.00)	3(75)	0(0.00)	1(25)
Gentamicin	10	8(66.7)	1(8.3)	3(25)	3(75)	0(0.00)	1(25)
Ofloxacin	5	3(25)	0(0.00)	9(75)	2(50)	0(0.00)	2(50)
Cefotaxime	25	11(91.7)	1(8.3)	0(0.00)	4(100)	0(0.00)	0(0.00)

Key: R-Resistant; I-Intermediate; S-Susceptible

The result of the overall susceptibility pattern of *Salmonella enterica* isolated from seafoods (Whelks, Oyster and Prawn) is shown in Table 7. While the results of the Multiple Antibiotic Resistance (MAR) Index of *S. enterica* isolated from seafood sold in the markets in Rivers State is as shown in Table 8. Generally, *Salmonella enterica* were resistant to Impenem/Cilastatin (97.5%) Augmentin (95%), Cefotaxime (92.5%) and Nitrofurantoin (90%) and sensitive to Ofloxacin (65%) (Table 7). All *Salmonella enterica* had MAR indices greater than 0.2 which indicates a high risk source of contamination (Table 8).

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Table 7: Overall Susceptibility Pattern of *Salmonella enterica* isolated from Oyster, Prawn and Whelks

Antibiotics	Conc. (µg)	*Salmonella enterica* (n=40)		
		Resistant n (%)	Intermediate n (%)	Susceptible n (%)
Ceftriaxone Sulbactam	45	30(75)	2(5)	8(20)
Nalidixic acid	30	37(9.5)	3(7.5)	0(0)
Cefexime	5	32(80)	2(5)	6(15)
Ampiclox	10	34(85)	3(7.5)	3(7.5)
Cefuroxime	30	35(87.5)	2(5)	3(7.5)
Nitrofurantoin	300	36(90)	1(2.5)	3(7.5)
Levofloxacin	5	32(80)	2(5.0)	6(15)
Impenem/Cilastatin	10	39(97.5)	0(0)	1(2.5)
Amoxicillin clavulanate	30	38(95)	0(0)	2(5)
Gentamicin	10	2767.5)	2(5)	11(27.5)
Ofloxacin	5	14(35)	0(0)	26(65)
Cefotaxime	25	37(92.5)	3(7.5)	0(0)

Key: R-Resistant; I-Intermediate; S-Susceptible

Table 8: Multiple Antibiotic Resistance Index of *S. enterica* isolated from Seafood in Rivers State

MAR Index	*Salmonella enterica* (n=40)		
	Oyster	Prawn	Whelks
0.2	0(0.0)	1(2.5)	1(2.5)
0.3	0(0.0)	0(0.0)	1(2.5)
0.4	1(2.5)	1(2.5)	1(2.5)
0.5	1(2.5)	0(0.0)	0(0.0)
0.6	1(2.5)	1(2.5)	1(2.5)
0.8	1(2.5)	1(2.5)	1(2.5)
0.9	3(7.5)	5(12.5)	6(15)
1.0	3(7.5)	4((10)	6(15)

Discussion

Seafoods are popular source of mineral and vitamin consumed by people worldwide neglecting its health implications. In Oyster, Prawn and Whelks samples, *Salmonella* counts were high in raw samples obtained from Creek road, Kaa and Bakana markets than the parboiled samples for the six (6) months with the Whelks samples having more *Salmonella* counts. This is because Whelks are scavengers, feeding on dead animal with high amount of *Salmonella*. Kumar *et al*. (2009) had similar counts from fresh seafood in India. Sampson *et al*. (2020) also recorded similar results in their works on cockles from Creek road market. The high *Salmonella* load in the sample from the Creek Road market, Kaa and Bakana is attributable to poor environmental conditions, ingestion of micro-organisms that reside in their natural habitat by the seafoods during feeding, poor handling by market vendors and sources of water used for washing and storage of samples before purchase (Takeda, 2011). The parboiled samples from the various markets had lower counts, because parboiling could eliminate some microorganisms from the samples (Odu *et al*., 2017).

The contamination of the seafoods by *Salmonella enterica* may be as a result of source of water used for preparation, distance between areas of catch and polluted areas where anthropogenic activities (human and animal faeces) is predominant (Takeda, 2011). Mama and Alemu, (2016) recorded similar values in a research on shellfish.

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The total *Salmonella* of the raw samples were above the limits specified by the International Commission on Microbiological Specifications for foods (ICMSF, 2002). The presence of *Salmonella* in seafood samples indicates poor hygiene and poor sanitary conditions, and the quality of seafoods depends on the quality of water from which the seafoods are harvested and the sanitary condition of the landing centres (Dons *et al*., 2011). The high prevalence of *Salmonella* in the seafood could also be attributed to the fact that *Salmonella* is halo-tolerant, they maintain a low level of ionic concentrations to synthesize compatible solute to balance the osmotic level inside the cytoplasm with the outer medium (Okonko *et al*., 2009). The results are in line with reports of other studies in Nigeria by various authors (Adagbada *et al*., 2011; Al-Hindi *et al*., 2011). It is now widely accepted that there is association between antimicrobial agents and the occurrence of resistance. Hence, the antimicrobials exert selective pressure on the organisms which is a key issue in epidemiological studies (Abdollahzadeh *et al*., 2016). The susceptibility results indicate greater number of the *Salmonella enterica* isolates were susceptible to Ofloxacin and Gentamicin and were highly resistant to Impenem/Cilastatin, Cefotaxime, Amoxicillin clavulanate, Nitrofurantoin, Cefuroxime, Nalidixic acid, Cefexime, Ampiclox, and Levofloxacin. Islam *et al*. (2008) who reported similar result in this study that *Salmonella* were resistant to Ceftazidime. Samantha *et al*. (2014) also found out that 100% of their *Salmonella* were resistant to Gentamicin and the resistance observed in the aminoglycosides like Gentamicin could be mediated by preventing the drugs from reaching the ribosomes which is their target site and this is usually achieved in two (2) ways: by altering the cell envelope which inhibits the uptake of the drug and via the modification of the drug by inactivating enzymes which is in disagreement with this current study showing that *Salmonella* were susceptible to Gentamicin. A similar work was done by Abdissa *et al.* (2017) which demonstrated susceptibility to Gentamicin. This drug (Gentamicin) binds to the cell inhibits protein synthesis and the acquisition of the aac gene by the organisms (Vakulenko and Mobashery, 2003).

In conclusion, the prevalence of *Salmonella enterica* in seafood in this study is considered a sanitary problem and may poses a risk to consumers. This study revealed a high *Salmonella* load in Whelks, Prawn and Oysters sold in Rivers State. The risk of *Salmonella enterica* infection was higher in the raw samples than the parboiled samples. The resistance of *Salmonella enterica* to several groups of antibiotics is a major concern which could pose a serious public health problem. The results indicated that Ofloxacin can be used as drug of choice for treatment *Salmonella enterica* associated foodborne diseases arising from consumption of seafoods. It is important that food preparation and handling be done properly, and that seafoods are cooked thoroughly to reduce the risk of food poisoning and enacting laws regarding the indiscriminate use of antibiotics.

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