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Prevalence, persistence and diversity of *Listeria* strains with antimicrobial resistance and virulence genes from fresh fruits in Southwest Nigeria

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ABSTRACT

Untreatable listeriosis and wastage could be traced to contaminated fruits. This study assessed *Listeria spp*, antimicrobial resistance and virulence genes in ready-for-sale fruits. *Listeria spp* was identified in 270 fruits: garden egg (90), tomato (90) and watermelon (90), were purchased from thirty markets, in Southwest Nigeria. *Listeria spp* were evaluated, identified and sequenced. Antimicrobial sensitivity assay (15 antibiotics), eighteen antimicrobial and nine virulence genes were screened for. *Listeria spp* 28 (100.00 %) at 66.25 MPN/g comprising of pathogenic (19) (*L. monocytogenes* 6 (21.43 %), *L. ivanovii* 5 (17.86 %), *L. seegligeri* 8 (28.57 %)) and non-pathogenic (9) (*L. welshimeri* 5 (17.86 %), *L. grayi* 2 (7.14 %) and *L. innocua* 1 (3.57 %)) strains were distributed in garden egg 8 (28.57 % at 56.63 MPN/g), tomato 14 (50.00 % at 54.29 MPN/g) and watermelon 6 (21.43 % at 57.00 MPN/g). Carbapenem, chloramphenicol, macrolides, tetracycline and folate resistant *Listeria* strains with highest prevalence were in fruit from Balogun 9 (60.00 %), Agege 8 (28.57 %) and Lekki 10 (45.45 %) in Lagos state. Virulent *L.* strains had five *L. monocytogenes,* two *L. ivanovii,* eight *L. seegligeri,* five *L. welshimeri,* two *L. innocua* and eight *L. grayi* in fruit from Lagos, Osun and Ondo States respectively. *Listeria monocytogenes, L. ivanovii* and *L. seegligeri* in fruit from Lagos State had *prfA, plcA* and *plcB* genes. Fruits could thereby be versatile route for various diverse virulent-resistant *Listeria* strains that could cause constant listeriosis and spoilage. However, there is need for more enforced, good and healthy handling of fruits on farms and in markets.

1. Introduction

Fruits and vegetables are a vital part of a healthy nutritious diet in Nigeria, comprising of bioactive compounds, vitamins, minerals, fibres and proteins. These components impart good nutrition, and obesity prevention, with antioxidative, anticarcinogenic, antidiabetic, and anticardiovascular disease components in consumers (World Health Organization WHO, 2023; World Health Organisation WHO, 2024). Over the years, the World Health Organization (WHO) estimated that both fruits and vegetables, possess healthy imparting constituents, though in varying proportions. Common fresh fruits in Nigeria are watermelon, pineapple, banana, pawpaw, citrus, mango, eggplant, tomato, and others (Dijkxhoorn et al., 2021). Fruits are more antioxidant, sugar (fructose and glucose), and calorie (Arias et al., 2022; Tassoult et al., 2021).

However, fruits could be a source of food spoilage and poisoning, if exposed to bacteria contamination (Alegbeleye et al., 2022). The amount of contamination in fruits varies with type, time of collection, season, transportation, packaging, market or storage temperature and humidity conditions, as well as poor hygiene, farming, processing, and serving practices (Panwar et al., 2024; Gatica et al., 2023).

Bacteria such as *Listeria* strains might not only result to fruits waste but they have been creating vast threat to food security and human health (Wu et al., 2019). These routed from contaminated farm soil, irrigation water, packing and harvesting tools, contact-surfaces, handlers (Iwu and Okoh, 2019). The pathogenic strains affect all age groups, including under 65 years, non-pregnant, and healthy persons (World Health Organization WHO, 2018). Meanwhile, neonates, elders,

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pregnant women, and immune-compromised individuals (that is, people with untreated HIV infection, cancer, diabetes, heart disease, organ transplant, or immunosuppressed patients) are more susceptible to listeriosis (Food Agriculture Organisation FAO, 2021).

Listeriosis was rated the third leading food-borne that leads to the death of about 260 and 25 % faetal loss annually (Center of Disease Control and Prevention CDC, 2024). This disease is revealed as reoccuring cutaneous, endophthalmitis, gastroenteritis fever, bacteremia, neurolisteriosis (meningitis, encephalitis, rhomboencephalitis), pneumonia, corneal ulcer, infected cerebrospinal fluid, skin as well as blood,

Table 1
Identified *Listeria* strains in fresh fruits of various markets in Southwest, Nigeria.

Fruits					Pathogenic and Non-Pathogenic *Listeria spp*								Significant Level			No of positive samples by quantitative methods (MPN/g)					
Towns	Markets	Sampling Time (year. month)	No of Samples collected	No of Homogenized Samples	No (%) of positive samples of *Listeria monocytogenes*	No (%) of positive samples of *Listeria ivanovii*	No (%) of positive samples of *Listeria seeligeri*	No (%) of positive samples of *Listeria welshimeri*	No (%) of positive samples of *Listeria innocua*	No (%) of positive samples of *Listeria grayi*	No (%) of positive samples of Other *Listeria spp*	No (%) of positive samples of *Listeria spp*	Σx^2	*df*	Σx^2 at p=0.05	<1	≥1-<10	≥10-<100	>100	Total	*Listeria spp* level (Fruits, MPN/g) X_s[a]
Alaba	Mile 12	2022.02	9	3	0 (0.00)	0 (0.00)	1 (33.33)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (9.09)	2.85	-	2.84	0	0	1	0	1	44.00
Ikorodu	Ile-Epo	2022.02	9	3	0 (0.00)	1 (25.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (9.09)	1.93	6	12.59	0	0	1	0	1	59.00
Badagry	Oyingbo	2022.02	9	3	1 (50.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (9.09)	4.68	12	21.03	0	0	1	0	1	37.00
Balogun	Agege	2022.03	9	3	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	-	-	-	0	0	0	0	0	0.00
Oyingbo	Musin	2022.02	9	3	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	-	-	-	0	0	0	0	0	28.00
Lekki	Oshodi	2022.02	9	3	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	-	-	-	0	0	0	0	0	0.00
Fagba	Lekki	2022.02	9	3	0 (0.00)	0 (0.00)	1 (33.33)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (9.09)	2.85	36	51.00	0	0	1	0	1	37.50
Agege	Balogun	2022.03	9	3	1 (50.00)	1 (25.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	2 (18.18)	2.49	42	58.12	0	1	1	0	2	39.00
Mile 12	Sabo	2022.02	9	3	0 (0.00)	0 (0.00)	1 (33.33)	1 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	2 (18.18)	5.70	48	65.17	0	0	2	0	2	46.50
Ile-Epo	Alaba	2022.02	9	3	0 (0.00)	2 (50.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	3 (27.27)	4.88	54	72.15	0	1	2	0	3	46.50
No (%) of positive samples of *Listeria spp* (Lagos State			90	30	2 (18.18)	4 (36.36)	3 (27.27)	1 (9.09)	0 (0.00)	1 (9.09)	0 (0.00)	11 (100.00)	25.38	-	72.15	0	2	9	0	11	42.55
No (%) of positive samples of *Listeria spp* (Lagos State/all states)), X_1[b]												11 (39.29)	11.11	-	17.27	0.00	5.50	41.45	0.00	33.43	
Osogbo	Igbona	2022.01	18	6	1 (33.33)	0 (0.00)	0 (0.00)	1 (33.33)	0 (0.00)	0 (0.00)	0 (0.00)	2 (18.18)	6.61	-	2.84	0	1	0	1	2	74.00
Osogbo	Orisunbare	2022.01	18	6	0 (0.00)	0 (0.00)	1 (33.33)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (9.09)	2.85	6	12.59	0	0	1	0	1	50.00
Osogbo	Ota-Efun	2022.01	18	6	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	1 (9.09)	4.68	12	21.03	0	0	1	0	1	37.50
Iwo	Odori	2022.01	18	6	0 (0.00)	0 (0.00)	1 (33.33)	1 (33.33)	0 (0.00)	0 (0.00)	0 (0.00)	2 (18.18)	5.70	18	28.89	0	0	1	1	2	94.00
Iwo	Oja Ale, Iwo	2022.01	18	6	0 (0.00)	0 (0.00)	1 (33.33)	1 (33.33)	0 (0.00)	0 (0.00)	0 (0.00)	2 (18.18)	5.70	24	26.42	0	0	1	1	2	91.00
Ilesha	Ilesha Atamokunsa	2022.01	18	6	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (9.09)	10.18	30	43.77	0	0	1	0	1	22.00
Iwo	Sabo Iwo	2022.01	18	6	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	-	36	51.00	0	0	0	0	0	25.00
Ifon Osun	Ifon Osun	2022.01	18	6	2 (66.67)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	2 (18.18)	9.36	42	58.12	0	1	1	0	2	49.00
Ife	Lagere	2021.12	18	6	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	-	-	-	0	0	0	0	0	0.00
Ife	Oja Titun	2022.01	18	6	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	-	-	-	0	0	0	0	0	0.00
No (%) of positive samples of *Listeria spp* (Osun State)			90	30	3 (27.27)	0 (0.00)	3 (27.27)	3 (27.27)	1 (9.09)	1 (9.09)	0 (0.00)	11 (100.00)	45.08		72.15	0	2	6	3	11	93.00
No (%) of positive samples of *Listeria spp* (Osun State/all states), X_2[b]												11 (39.29)	28.93	6	11.07	0.00	5.80	36.75	95.00	43.56	
Akure	Okitipupat	2021.12	18	6	1 (100.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	1 (100.00)	3 (50.00)	5.05	-	2.84	0	1	1	1	3	37.00
Ondo	Boloru nduro Ondo	2021.11	18	6	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	-	6	0	0	0	0	0	0	0.00
Akure	Owena	2021.11	18	6	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (16.67)	1.93	12	21.03	0	0	1	0	1	33.00
Ondo	Akure Oja Oba	2021.12	18	6	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	-	18	28.89	0	0	0	0	0	0.00
Okitipupa	Iloro	2021.12	18	6	0 (0.00)	0 (0.00)	1 (50.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (16.67)	2.85	24	26.42	0	0	1	0	1	26.00
Owena	Isinkan	2021.11	18	6	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	-	-		0	0	0	0	0	32.00
Alade	Alade	2021.12	18	6	0 (0.00)	0 (0.00)	1 (50.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (16.67)	2.85	36	51.00	0	0	1	0	1	53.00
Ikare	Ikare Oja-Oba	2021.12	18	6	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	-	-	-	0	0	0	0	0	0.00
Owo	Shasha	2021.11	18	6	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	-	-	-	0	0	0	0	0	0.00
Owo	Owo Oja Oba	2030.11	18	6	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	-	-	-	0	0	0	0	0	0.00
No (%) of positive samples of *Listeria spp* (Ondo State)			90	30	1 (16.67)	1 (16.67)	2 (33.34)	1 (16.67)	0 (0.00)	0 (0.00)	1 (16.67)	6 (100.00)	12.67	-	2.84	0	1	4	1	6	75.33
No (%) of positive samples of *Listeria spp* (Ondo State/all states), ΣX_3[b]												6 (21.43)	17.90	12	21.03	0.00	7.00	36.67	112.00	45.20	
No (%) of positive samples of *Listeria spp* (Southwest), X_t[b]					6 (21.43)	5 (17.86)	8 (28.57)	5 (17.86)	1 (3.57)	2 (7.14)	1 (3.57)	28 (100..00)	57.93	18	28.87						
	Σx^2				10.630	5.932	13.394	24.916	1.088	-10	-12										
	df				2.84	5.99	9.49	12.59	15.51	18.31	21.03										
	p=0.05																				

X^a Incidence of *Listeria* strain per state fruits; X^b Cumulative incidence of *Listeria* strain per market sampling; ΣX_4^b Cumulative incidence of *Listeria* strain per Southwest sampling; Σx^2: Cumulative incidence of *Listeria* strain; *df*: Degree of Freedom

eye infections, and intrauterine or cervical infection (constant abortion, stillbirth and septicaemia) in pregnant and lactating women (World Health Organization WHO, 2018; Agboola and Bisi-Johnson, 2023). Nonetheless, environmental factors with geographical zones affect the prevalence level of *L. spp* (Agboola and Bisi-Johnson, 2023; Fatunla et al., 2025). Thus, outbreak of listeriosis, linked with fruits has been found more virulent and also reoccurring in specific developed part of the world (Geteneh et al., 2022; Khalila et al., 2023). Meanwhile, documentation of virulent-resistant *L. spp* in food and related outbreak, is still ongoing (Khalila et al., 2023; Olanbiwoninu et al., 2024a). This research assessed the prevalence, persistence and diversity of *L. spp* associated with fruits, within the markets and across the states of the Southwest, Nigeria. Also, *Listeria* strains (*L. monocytogenes, L. ivanovii, L. seegligeri, L. welshimeri, L. grayi* and *L. innocua*) from fruits (at various markets, that are majorly consumed raw or eaten after minimal processing, in three states of the Southwest, Nigeria) were characterized for virulence and antimicrobial genes.

2. Methodology

2.1. Study area and sample collections

The farmers' market locations of this research (longitude 2° 31', 6° 00' East and latitude 6° 21' and 8° 37' N) were three states of South-Western, Nigeria. Vegetables were purchased between year 2021 and 2022. Fruits (n = 270) were purchased randomly from 30 open markets in Oyo, Osun, and Ondo States. These comprised of 90 garden eggs, 90 tomato, and 90 watermelons (as shown in Table 1). They were immediately transported in ice boxes to the laboratory for microbiological analysis.

2.2. Isolation of Listeria spp and identification

Listeria spp was isolated according to PHE (Public Health England PHE, 2018), by pre-enriched incubation in serial diluted Half-Fraser Broth and Full-Fraser Broth (OXOID, CM0895 ISO, United Kingdom) at 37 °C for 24–48 h. Streaking of the loopful or 0.5 ml from the broth was respectively done or poured on both the Palcam Agar (Oxoid, CM0877) and *Listeria* Selective Agar Base (Oxford Formulation. CM0856) plate. Thereafter incubation was done at 37 °C for 24–48 h.

Pure isolates were biochemically isolated using the Microbact Listeria 12 L Identification System (Oxoid, MB1128, UK), according to the Thermofisher Scientific Inc ©2001–2025 Oxoid Limited. Before this, the purified *Listeria spp* isolates were characterized by gram-staining (Dubey, 2014), catalase test (Kanganwiro, 2015) and oxidase test (Ali and Asmaa, 2017).

All *Listeria spp (x) counted were estimated to base-ten logarithms using the minimum and* maximum values set as 0.15 MPN/g $\leq x \geq$ 110 MPN/g. The positive samples prevalence and every bacteria counts were done in triplicate Levels.

2.2.1. DNA extraction

For further identification, conventional boiling (Mthembu et al., 2019) and DNA kit (Yunjie and Oluseyi, 2013) extraction methods were used on the biochemically purified and identified isolates. Following (Mthembu et al., 2019) pure 24 h cultured *Listeria* isolates were collected in 1 ml of sterile water. Wash-centrifugation was done twice (with 500 µL sterile distilled water, at 14,000 ×g for 5 min). Then, the pellets (in 200 µL of sterile distilled water) were paced in a heating block at 100 °C (Labnet, FL, USA) for 10 min and heat-shocked (for 15 min). Centrifuged supernatant DNA (at 14,000 × g for 5 min) was stored (at −20 °C).

The Bioneer DNA extraction kit (Accuprep) was employed to obtain genomic DNA from *Listeria spp* cultures, following the Bioneer Corporation (Bioneer Corporation, 2004). The obtained DNA was stored at −20 °C till when it was needed.

2.2.2. Polymerase chain reaction amplification

In this research work, the required primers and necessary conditions used were presented in Supplementary Table S1. The protocol was carried out from 20 µl of pre-mix (Accupower), according to Yunjie and Oluseyi (2013). The purity, concentration, and integrity of DNA were assessed using a spectrophotometer (Nanodrop Lite, Thermo Fisher Scientific, Waltham, MA, USA). One hundred milliliters of TAE buffer, made of 1.6 M Tris-EDTA, and 0.025 M acetic acid was used. DNA ladder (5 µl) and negative-positive control were loaded. Electrophoresis (at 80 volts for 45 min) was done, after which, the gel was virtualized in a UV trans-illuminator. Using the QIAquick Gel Extraction Kit and the QIAquick PCR & Gel Cleanup Kit (cat. nos. 28704, 28706, 28506, and 28115), bands were purified for sequencing.

2.2.3. Sequencing

DNA sequencing was executed at International Institute of Tropical Agriculture (IITA) Bioresource Center, Ibadan, Oyo State, Nigeria. The purified bands from 16S rRNA gene PCR products for the *Listeria spp* isolates were subjected to the Bigdye Terminator V3.1 cycle sequencing kit (Perkin-Elmer) in an Applied Biosystems 3130 Sequencer (ABI, USA). The purified sequence reaction with Centrisep (spin column) was identified according to (Applied Biosystems, 2010) protocol, blasted and analyzed using Basic Local Alignment Search Tool (BLAST®) (https://blast.ncbi.nlm.nih.gov/Blast.cgi).

2.3. Antimicrobial susceptibility test

Listeria spp (n = 28) were tested for their susceptibility against fifteen common antimicrobial for the control of bacteria infections in Nigeria, using Kirby Bauer disk diffusion, described by the Clinical and Laboratory Standards Institute (CLSI) (Clinical and Laboratory Standards Institute, CLSI, 2021). Discs with amoxillin-clavulanic (30 µg), tetracycline (30 µg), ciprofloxacin (5 µg), imipenem (10 µg), ampicillin (10 µg), erythromycin (15 µg), azithromycin (15 µg), trimethroprim-sulphanamide (25 µg), gentamycin (10 µg), streptomycin (30 µg), chloramphenicol (30 µg), cefotaxone (30 µg), cetriazone (30 µg), vancomycin (5 µg) and clindamycin (2 µg) were used. Clear zone diameters were recorded, after incubation for 24 hours. Interpretation was done as susceptible, intermediate, and resistant for each isolate.

2.4. Antimicrobial resistance genes assay

The presence of eighteen antimicrobial resistance genes (ARG): *gyrA, gyrB*, *NDM*, *KPC, IMP*, *SHV*, *TEM, CTX, vanA, vanB*, *catA, AadA, tetM*, *dfrA14*, *mefA, msrA, ereA,* and *ermX* were examined in 28 *Listeria spp* using primers and PCR conditions shown in Supplementary Table S2. The PCR products (with negative and positive) were determined by agarose gel electrophoresis using ethidium bromide as a stain visualized under UV trans-illuminator.

2.5. Virulence genes assay

The presence of *prs, hlyA, clpE, plcA, plcB, prf, iniB* and *RADP* genes were likewise assessed on each identified isolates, according to Agboola and Bisi-Johnson (2023). The primers and PCR conditions for the identification of virulence genes were also presented in Supplementary Table S1. Agarose gel electrophoresis was used to confirm the genes.

2.6. Data analysis

The proportion of all positive isolates were quantified by chi-square (at p = 0.05, significant level) using Microsoft Excel spreadsheet (WPS Office, 2025 version).

3. Results

3.1. Isolation of Listeria spp and identification

Ninety presumptive Listeria isolates were isolated from 270 fresh fruits, but 28 isolates were identified to be *Listeria spp* (consisting of pathogenic (n = 19) and non-pathogenic strains, n = 9). From Table 1, dominant *L. spp* 28 (100.00 %) identified were *L. monocytogenes* 6 (21.43 %), *L. ivanovii* 5 (17.86 %), *L. seegligeri* 8 (28.57 %), *L.welshimeri* 5 (17.86 %), *L. grayi* 2 (7.14 %) and *L. innocua* 1 (3.57 %). Others were classified under other *L. spp* 1 (3.57 %). This implies that in the fruit samples *Listeria seegligeri* 8 (28.57 %) has the highest frequency rate.

Table 2
Identified *Listeria* strains in specific fresh fruits of various markets in Southwest, Nigeria.

Markets	Garden Egg	Tomato	Watermelon	Fruits	Σx^2	*df*	Σx^2 at p = 0.05
	Pathogenic and Non-Pathogenic *Listeria spp* in Fruits						
Lagos State							
Mile 12	1 (33.33)	0 (0.00)	0 (0.00)	1 (9.09)	2.85	0	-
Ile-Epo	0 (0.00)	1 (20.00)	0 (0.00)	1 (9.09)	1.38	2	5.99
Oyingbo	0 (0.00)	1 (20.00)	0 (0.00)	1 (9.09)	1.38	4	7.82
Agege	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	-	-	-
Musin	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	-	-	-
Oshodi	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	-	-	-
Lekki	0 (0.00)	0 (0.00)	1 (33.33)	1 (9.09)	1.38	12	21.03
Balogun	1 (33.33)	0 (0.00)	1 (33.33)	2 (18.18)	1.30	14	23.69
Sabo	0 (0.00)	1 (20.00)	1 (33.33)	2 (18.18)	0.56	16	26.30
Alaba	1 (33.33)	2 (40.00)	0 (0.00)	3 (27.27)	1.70	18	28.87
No (%) of positive samples of *Listeria spp* (Lagos State), X_1^b	3 (27.27)	5 (45.45)	3 (27.27)	11 (100.00)	10.32	-	-
No of positive samples by quantitative methods (MPN/g)							
< 1	0	0	0	0			
≥1-<10	1	1	0	2			
≥10-<100	2	4	3	9			
>100	0	0	0	0			
Total	3	5	3	11			
Listeria spp level (Fruits, MPN/g), X_5^a	32.33	37.60	68.30	41.64			
Osun State							
Igbona	1 (25.00)	0 (0.00)	1 (33.33)	2 (18.18)	1.21	-	-
Orisunbare	0 (0.00)	1 (25.00)	0 (0.00)	1 (9.09)	1.75	2	5.99
Ota Efun	1 (25.00)	0 (0.00)	0 (0.00)	1 (9.09)	1.75	4	7.82
Odori	0 (0.00)	1 (25.00)	1 (33.33)	2 (18.18)	-	-	-
Oja Ale, Iwo	0 (0.00)	1 (25.00)	1 (33.33)	2 (18.18)	-	-	-
Ilesha Atamokunsa	1 (25.00)	0 (0.00)	0 (0.00)	1 (9.09)	-	-	-
Sabo Iwo	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	-	-	-
Ifon Osun	1 (25.00)	1 (25.00)	0 (0.00)	2 (18.18)	0.75	14	23.69
Lagere	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	-	16	26.30
Oja Titun	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	-	18	28.87
No (%) of positive samples of *Listeria spp* (Osun State), X_2^b	4 (36.36)	4 (36.36)	3 (27.27)	11 (100.00)	10.32	2	-
No of positive samples by quantitative methods (MPN/g)							
< 1	0	0	0	0			
≥1-<10	2	0	0	2			
≥10-<100	2	3	1	6			
>100	0	1	2	3			
Total	4	4	3	11			
Listeria spp level (Fruits, MPN/g), X_5^a	36.50	60.50	95.00	64.81			
Ondo State							
Okitipupat	1 (100.00)	2 (40.00)	0 (0.00)	3 (50.00)	0.60	-	-
Bolorunduro Ondo	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	-	2	5.99
Owena	0 (0.00)	1 (20.00)	0 (0.00)	1 (16.67)	0.20	4	7.82
Akure Oja Oba	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	-	-	-
Iloro	0 (0.00)	1 (20.00)	0 (0.00)	1 (16.67)	-	-	-
Isinkan	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	-	-	-
Alade	0 (0.00)	1 (20.00)	0 (0.00)	1 (16.67)	0.20	12	21.03
Ikare Oja Oba	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	-	-	-
Shasha	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	-	-	-
Owo Oja Oba	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	-	-	-
No (%) of positive samples of *Listeria spp* (Ondo State), ΣX_3^b	1 (17.67)	5 (83.33)	0 (0.00)	6 (100.00)	17.29	4	21.29
No (%) of positive samples of *Listeria spp* (Southwest), X_4^b	8 (28.57)	14 (50.00)	6 (21.43)	28 (100.00)	-	-	-
Σ X	9.45	22.85	5.63	37.93			
df	0	2	4				
p = 0.05	2.84	5.99	9.49				
No of positive samples by quantitative methods (MPN/g)							
< 1	0	0	0	0			
≥1-<10	0	1	0	1			
≥10-<100	1	3	0	4			
>100	0	1	0	1			
Total	1	5	0	6			
Listeria spp level (Fruits, MPN/g)	71	48.40	0	52.17			
Overall Total	8	14	6	28			
Overall *Listeria spp* level (Fruits, MPN/g), X_5^a	56.63	54.29	57.00	66.25			

X^a Incidence of *Listeria* strain per state fruits; X^b Cumulative incidence of *Listeria* strain per market sampling; ΣX_4^b Cumulative incidence of *Listeria* strain per Southwest sampling; Σx^2: Cumulative incidence of *Listeria* strain; *df*: Degrese of Freedom

Respective incidence rate and geometric mean of *L. spp* in Lagos, Osun, and Ondo State were seen to be 11 (39.29 %), 11 (39.29 %), and 6 (21.43 %) with 33.43, 43.56 and 45.20 MPN/g. The highest prevalence of *L. spp* of 3 (27.27 %) and 3 (50.00 %) with a geometric mean of 59.00 MPN/g and 37.00 MPN/g was observed in Ile-Epo (Lagos State) and Okitipupa (Ondo State) markets respectively. There is no significant difference of $p \geq 0.05$ from amidst positive *Listeria* strains in the fruits from each market, but significant difference of $p \geq 0.05$ were found in positive samples with *L. monocytogenes, L. seegligeri* and *L. grayi.*

All isolates (Table 1) in Lagos fruit were positive except *L. innocua* with 0 (0.00 %) prevalence. The proportion of the *L. spp* of 11 (100.00 %), in Lagos State showed the highest value in *L. ivanovii* 4 (36.36 %). Other proportional values were *L. monocytogenes* 2 (18.18 %), *Listeria seegligeri* 3 (27.27 %), *L.welshimeri* 1 (9.09 %), *L. grayi* 1 (9.09 %) and other *L. spp* 0 (0.00 %). All the marketed fruit had at least 1 (9.09 %) of *L. spp* except Balogun, Oyingbo and Lekki markets (as at the time of sample collection). Likewise, none of the geometric mean is greater than 100 MPN/g.

On the other hand, in Osun State, *L. ivanovii* was found with a minimal value of 0 (0.00 %) (Table 1). Fruit from this state had at least 1 (9.09 %) of *L. spp* with 11 (100.00 %) except Sabo-Iwo, Lagere Ife and Oja-Titun Ife markets. Prevalence value of 3 (27.27 %) was seen in *L. monocytogenes, L. welshimeri* and *L. seegligeri* but only 1 (9.09 %) was in *L. grayi.* Three *Listeria spp* (from fruit samples gotten from Igbona, Odori, and Oja-Ale markets) were found to have geometric mean above 100 MPN/g.

For Ondo State fruit (Table 1), *L. seegligeri* with 2 (33.34 %) carried the highest prevalence, out of 6 (100.00 %) *L. spp*. However, others had 2 (16.67 %) except *L. ivanovii* and *L. grayi* with a minimal value of 0 (0.00 %). Fruits from Okitipupa, Owena, Iloro, and Alade markets were found with 1 (16.67 %) *L. spp*. Only one *L. spp* had a geometric mean above 100 MPN/g with the value of 112 MPN/g in fruits from the Okitipupa market.

As presented in Table 2, the respective distribution and geometric mean of *L. spp* of 28 (100.00 %) at 66.25 MPN/g in garden egg, tomato, and watermelon were 8 (28.57 %), 14 (50.00 %), and 6 (21.43 %) at 56.63, 54.29 and 57.00 MPN/g respectively. Thus, in Lagos, Osun, and Ondo States, tomatoes carried the highest incidence rates of 5 (45.45 %), 4 (36.36 %), and 5 (83.33 %) respectively, however, garden eggs from Osun State had 4 (36.36 %). Two identified *L. spp* was discovered in tomatoes from Alaba market in Lagos State. None of the *L. spp* from each fruit was observed to be above 100 MPN/g. No significant difference of $p \geq 0.05$ were seen from positive *Listeria* strains in fruits from the market, but significant difference of $p \geq 0.05$ were found in positive *Listeria* strains from garden egg and tomato.

Garden egg 5 (26.32 %) contained *L. monocytogenes* 4 (66.67 %) (originated from Balogun, Igbona, Ifon Osun and Okitipupa markets) and *L. seegligeri* 1 (20.00 %) (from Mile 12 market) (Table 3). This observation was also seen in tomato 10 (52.63 %) which comprised *L. monocytogenes* 2 (33.33 %) (from Oyigbo and Ifon Osun markets), *L. ivanovii* 4 (80.00 %) (from Ile-Epo, Alaba and Owena marketed tomato) and *L. seegligeri* 4 (50.00 %) (from Orisunbare, Odori, Iloro and Alade marketed tomato). Similarly, watermelon had a prevalence of 4 (21.05 %) including *L. ivanovii* 1 (20.00 %) (from Balogun marketed watermelon) and *L. seegligeri* 3 (37.50 %) (from Lekki, Sabo-Ikorodu and Oja-Ale Iwo marketed watermelon). There is no significant difference of $p \geq 0.05$, found in positive pathogenic *Listeria* strains in fruits.

However, for the non-pathogenic strains, garden egg 3 (33.33 %) with *L. grayi* 1 (20.00 %) (from Ota-Efon market) and *Listeria innocua* 2 (100.00 %) (from Alaba and Ilesha-Atamokunsa markets) (Table 4). Tomato 4 (44.44 %) contained *L. welshimeri* 3 (60.00 %) (from Sabo-Ikorodu, Oja-Ale Iwo and Okitipupa markets) and other *L. spp* 1 (100.00 %) (from Okitipupa market). Assessment of *L. welshimeri* in watermelon 2 (22.22 %) revealed to have 2 (40.00 %) (from Igbona and Odori markets). Significant difference of $p \geq 0.05$ were found in positive *Listeria innocua* in garden egg.

3.2. Antimicrobial susceptibility test

Out of 28 *L. spp,* 19 pathogenic strains were resistant to at least one antimicrobial used in this study (Table 5). More so, from the remaining 9 non-pathogenic strains, 8 were seen to be resistant to at least one of the utilized antimicrobials, from this study. About 5 *L. welshimeri* (n = 1, n = 3 and n = 1), 2 *L. grayi* (n = 1, n = 1 and n = 0), and 1 *L. innocua* (n = 0, n = 1 and n = 0) were found in fresh fruits, purchased from Lagos, Osun and Ondo in variant (Table 6).

3.3. Antimicrobial resistance genes assay

About 6 *Listeria monocytogenes,* 5 *Listeria ivanovii* and 8 *Listeria seegligeri,* carrying resistance genes were found in fruit from Lagos, Osun and Ondo State with respective *Listeria monocytogenes* (n = 2, n = 3 and n = 0), *Listeria ivanovii* (n = 4, n = 0 and n = 1) and *Listeria seegligeri* (n = 3, n = 3 and n = 2). Garden egg, tomatoes and watermelon had incidence of fluoroquinolone (*gyrA* and *gyrB* genes), carbapenem (*NDM*, *KPC,* and *IMP* genes), Extended-Spectrum beta-Lactamase Producing (ESBL) (*SHV*, *TEM* and *CTX* genes) activity, vancomycin (*vanA and vanB* genes), chloramphenicol (*catA* gene), aminoglycoside (*AadA* gene), tetracycline (*tetM* gene), folates (*dfrA14* gene) and macrolides (*mefA, msrA, ereA* and *ermX* genes) in *Listeria spp* (n = 18) from respective Lagos (n = 9), Osun (n = 6) and Ondo (n = 3) States. From the tables, $mefA_1$, $MsrA_1$, $ereA_1$, and $ermX_1$ with $mefA_2$, $MsrA_2$ $ereA_2$ and $ermX_2$ represent antimicrobial resistance gene (ARG, macrolides) for Erythromycin and azithromycin respectively (Table 5).

The resistant pathogenic *Listeria spp* identified in fruits from Lagos, Osun and Ondo States (Table 5) had a prevalence of 15 (23.08 %), 28 (43.08 %), and 22 (35.85 %); 13 (48.15 %), 0 (0.00 %) and 14 (51.85 %) as well as 0 (0.00 %), 7 (30.43 %) and 16 (69.57 %) for *L. monocytogenes, L. ivanovii* and *L. seegligeri* respectively. This revealed that the highest incidence of antimicrobial resistance gene (ARG) was in *L. monocytogenes, L. ivanovii* and *L. seegligeri* from fruits at Lagos state. Significant difference of $p \geq 0.05$ were not found in antimicrobial resistance genes from *L. spp.* From Lagos State, there were no resistant *L. monocytogenes, L. ivanovii* and *L. seegligeri* in watermelon, garden egg, and tomato. The highest frequency rates of 9 (60.00 %), 8 (28.57 %), and 10 (45.45 %) were observed in Balogun, Agege, and Lekki marketed garden egg, tomato, and watermelon severally. These *L. monocytogenes, L. ivanovii,* and *L. seegligeri* were carbapenem, chloramphenicol, macrolides, tetracycline, and folate resistant (Table 5).

None of *L. ivanovii* in Osun State fruits samples carried ARG but highest incidence rate of 6 (46.15 %, comprising of *TEM*, *tetM*, $mefA_2$, $Aad6_2$, and *vanB*) was seen in *L. monocytogenes* from Ifon-Osun market in garden egg sample (Table 5). Contrarily, there were no *L. monocytogenes* with ARG in Ondo State fruit samples. Only *L. ivanovii* (from Owena market) and *L. seegligeri* (from Iloro and Alade markets) of tomato samples carried ARG with prevalence of 7 (100.00 %, *tetM, gyrA, NDM, KPC, dfrA14,* $Aad6_1$ and *vanA*), 7 (43.75 %, *tetM,* $mefA_1$ *dfrA14, ereA1, mefA2,* $MsrA_2$, and *vanA*) and 9 (56.25 %, *NDM, KPC,* $mefA_1$, *ereA1,* $MsrA_1$, *mefA2, dfrA14, catA,* and *vanB*) respectively.

Incidence 8 (53.33 %), 0 (0.00 %), and 7 (46.67 %) of ARG were in non-pathogenic strains detected from fruits at Lagos State; 12 (75.00 %), 2 (12.50 %) and 2 (12.50 %) in Osun State; and 4 (100.00 %), 0 (0.00 %) and 0 (0.00 %) from Ondo State (Table 6). Significant difference of $p \geq 0.05$ were found in antimicrobial resistance genes from *L. welshimeri* and *L. grayii* from tomato. Tomato from Lagos (at Sabo-Ikorodu and Alaba markets differently had *L. welshimeri* 8 (100.00 %, having 1 (12.50 %) of *tetM, NDM, KPC,* $mefA_1$, *ermX1, dfrA14,* $Aad6_2$ and *catA*) and *L. grayi* 7 (100.00 % with 1 (14.29 %) of *SHV*, *CTX*, $mefA_1$, *dfrA14*, *Aad6*, *catA* and *vanB*). Antimicrobial resistance genes were similarly found in *Listeria welshimeri, L. grayi* and *L. innocua* from tomato from Oja-Ale Iwo 2 (16.67 %, $ermX_2$ and *dfrA14* genes), Ota-Efun 2 (100.00 %, $MsrA_1$ and $ermX_1$ genes) and Ilesha-Atamokunsa 2 (100.00 %, $ermX_1$ and $mefA_1$ genes) markets, respectively in Osun State. *L. welshimeri* was

Table 3
Identified specific pathogenic *Listeria* strains in specific fresh fruits of various markets in Southwest, Nigeria.

Markets	Garden Egg	Tomato	Watermelon	Fruit	Garden Egg	Tomato	Watermelon	Fruit	Garden Egg	Tomato	Watermelon	Fruit
	Pathogenic *Listeria spp*											
	No (%) of positive samples of *Listeria monocytogenes*				No (%) of positive samples of *Listeria ivanovii*				No (%) of positive samples of *Listeria seegligeri*			
Mile 12	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	1 (33.33)
Ile-Epo	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (33.33)	0 (0.00)	1 (25.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Oyingbo	0 (0.00)	1 (100.00)	0 (0.00)	1 (50.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Agege	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Musin	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Oshodi	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Lekki	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (50.00)	1 (33.33)
Balogun	1 (100.00)	0 (0.00)	0 (0.00)	1 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	1 (25.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Sabo	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (50.00)	1 (33.33)
Alaba	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	2 (66.67)	0 (0.00)	2 (50.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
No (%) of positive samples of *Listeria spp* (Lagos State)	1 (50.00)	1 (50.00)	0 (0.00)	2 (100.00)	0 (0.00)	3 (75.00)	1 (25.00)	4 (100.00)	1 (33.33)	0 (0.00)	2 (66.66)	3 (100.00)
No (%) of positive samples of *Listeria spp* (Lagos State/all states)				2 (33.33)				4 (80.00)				3 (37.50)
Igbona	1 (50.00)	0 (0.00)	0 (0.00)	1 (33.33)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Orisunbare	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (50.00)	0 (0.00)	1 (33.33)
Ota Efun	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Odori	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (50.00)	0 (0.00)	1 (33.33)
Oja Ale, Iwo	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	1 (33.33)
Ilesha Atamokunsa	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Sabo Iwo	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Ifon Osun	1 (50.00)	1 (100.00)	0 (0.00)	2 (66.67)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Lagere	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Oja Titun	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
No (%) of positive samples of *Listeria spp* (Osun State)	2 (100.00)	1 (100.00)	0 (0.00)	3 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	2 (100.00)	1 (100.00)	3 (100.00)
No (%) of positive samples of *Listeria spp* (Osun State/all states)				3 (50.00)				0 (0.00)				3 (37.50)
Okitipupa	1 (100.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Bolorunduro Ondo	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Owena	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Akure Oja Oba	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Iloro	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (50.00)	0 (0.00)	1 (50.00)
Isinkan	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Alade	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (50.00)	0 (0.00)	1 (50.00)
Ikare Oja Oba	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Shasha	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Oja-Oba, Owo	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
No (%) of positive samples of *Listeria spp* (Ondo State)	1 (100.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (100.00)	0 (0.00)	2 (100.00)	0 (0.00)	2 (100.00)
No (%) of positive samples of *Listeria spp* (Ondo State/all states)				1 (16.67)				1 (20.00)				2 (25.00)
No (%) of positive samples of *Listeria spp* (Southwest)	4 (66.67)	2 (33.33)	0 (0.00)	6 (100.00)	0 (0.00)	4 (80.00)	1 (20.00)	5 (100.00)	1 (12.50)	4 (50.00)	3 (37.50)	8 (100.00)
No (%) of positive samples of *Listeria spp* (Southwest)				6 (31.58)				5 (26.32)				8 (42.11)
ΣX^2	0.25	0.50	-	0.75	-	0.06	0.25	0.31	1.67	2.67	1.44	5.78
df	0	2	4	0	0	2	4	2	0	2	4	4
p = 0.05	2.84	5.99	9.49	2.84	2.84	5.99	9.49	5.99	2.84	5.99	9.49	9.49

ΣX_4^b Cumulative incidence of *Listeria* strain per Southwest sampling; Σx^2: Cumulative incidence of *Listeria* strain; *df*: Degrese of Freedom

Table 4
Identified specific non-pathogenic *Listeria* strains in specific fresh fruits of various markets in Southwest, Nigeria.

Markets	Garden Egg	Tomato	Watermelon	Fruit	Garden Egg	Tomato	Watermelon	Fruit	Garden Egg	Tomato	Watermelon	Fruit	Garden Egg	Tomato	Watermelon	Fruit
	Non-Pathogenic *Listeria spp*															
	No (%) of positive samples of *Listeria welshimeri*				No (%) of positive samples of *Listeria grayi*				No (%) of positive samples of *Listeria innocua*				No (%) of positive samples of Other *Listeria spp*			
Mile 12	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Ile-Epo	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Oyingbo	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Agege	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Musin	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Oshodi	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Lekki	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Balogun	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Sabo	0 (0.00)	1 (100.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Alaba	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
No (%) of positive samples of *Listeria spp* (Lagos State)	0 (0.00)	1 (100.00)	0 (0.00)	1 (100.00)	1 (100.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
No (%) of positive samples of *Listeria spp* (Lagos State/all states)				1 (20.00)				1 (50.00)				0 (0.00)				0 (0.00)
Igbona	0 (0.00)	0 (0.00)	1 (100.00)	1 (33.33)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Orisunbare	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Ota Efun	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00
Odori	0 (0.00)	0 (0.00)	1 (100.00)	1 (33.33)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00
Oja Ale, Iwo	0 (0.00)	1 (100.00)	0 (0.00)	1 (33.33)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00
Ilesha Atamokunsa	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00
Sabo Iwo	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00
Ifon Osun	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00
Lagere	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00
Oja Titun	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
No (%) of positive samples of *Listeria spp* (Osun State)	0 (0.00)	1 (33.33)	2 (66.67)	3 (100.00)	1 (100.00)	0 (0.00)	0 (0.00)	1 (100.00)	1 (100.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	0 (0.00	0 (0.00
No (%) of positive samples of *Listeria spp* (Osun State/all states)				3 (60.00)				1 (50.00)				1 (100.00)				0 (0.00
Okitipupa	0 (0.00)	1 (100.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (100.00)
Bolorunduro Ondo	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Owena	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Akure Oja Oba	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Iloro	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Isinkan	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Alade	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Ikare Oja Oba	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Shasha	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Oja-Oba, Owo	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
No (%) of positive samples of *Listeria spp* (Ondo State)	0 (0.00)	1 (100.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (100.00)

(*continued on next page*)

Table 4 (*continued*)

Markets	Garden Egg	Tomato	Watermelon	Fruit	Garden Egg	Tomato	Watermelon	Fruit	Garden Egg	Tomato	Watermelon	Fruit	Garden Egg	Tomato	Watermelon	Fruit
	Non-Pathogenic *Listeria spp*				No (%) of positive samples of *Listeria welshimeri*				No (%) of positive samples of *Listeria grayi*				No (%) of positive samples of *Listeria innocua*				No (%) of positive samples of Other *Listeria spp*			
No (%) of positive samples of *Listeria spp* (Ondo State/all states)					1 (20.00)				0 (0.00)				0 (0.00)				1 (100.00)			
No (%) of positive samples of *Listeria spp* (Southwest)	0 (0.00)	3 (60.00)	2 (40.00)		5 (55.56)	2 (100.00)	0 (0.00)	0 (0.00)	2 (100.00)				1 (20.00)	0 (0.00)	0 (0.00)		1 (100.00)	0 (0.00)	0 (0.00)	
No (%) of positive samples of *Listeria spp* (Southwest)					5 (55.56)				2 (22.22)				1 (11.11)				1 (100.00)			
ΣX^2	-	3.06	8.57	11.63		-	-	-		3.50	4.00	3.50	11.00				ΣX^2 -		3.06	8.57
df	0	2	4			0	2	4		0	2	4					df	0	2	4
p = 0.05	2.84	5.99	9.49			2.84	5.99	9.49		2.84	5.99	9.49					p = 0.05	2.84	5.99	9.49

ΣX_4^b Cumulative incidence of *Listeria* strain per Southwest sampling; Σx^2: Cumulative incidence of *Listeria* strain; *df*: Degree of Freedom
ΣX_4^b Cumulative incidence of *Listeria* strain per Southwest sampling; Σx^2: Cumulative incidence of *Listeria* strain; *df*: Degree of Freedom

likewise seen in Odori-marketed watermelon with the prevalence of 5 (41.67 %). In Ondo State, *L. welshimeri* 4 (100.00 %) was observed to carry *NDM, KPC, Aad6,* and *vanA* genes.

3.4. Virulence genes assay

Fifteen pathogenic *Listeria* strains (Table 7) had at least one virulence gene out of the total of nineteen and an overall number of twenty-eight *L. spp.* Five *L. monocytogenes* (n = 2, n = 3 and n = 0), two *L. ivanovii* (n = 1, n = 0 and n = 1), and eight *L. seegligeri* (n = 3, n = 3 and n = 2) were observed to carry at least one of two of the virulence genes, in Lagos, Osun and Ondo States respectively. The virulence genes from fruit samples in Ondo Lagos, Osun and Ondo States from *L. monocytogenes, L. ivanovii* and *L. seegligeri* had incidence rate of 12 (33.33 %), 5 (13.89 %), and 19 (52.78 %); 21 (55.26 %), 0 (0.00 %) and 17 (44.74 %) as well as 0 (0.00 %), 6 (31.58 %) and 13 (68.42 %) respectively. Higher virulence gene frequency rate was found in *L. monocytogenes* from fresh fruit Osun state samples.

L. monocytogenes in garden egg (from Balogun market, 5, 41.67 %) and tomato (from Oyingbo market, 7, 58.33 %); *Listeria ivanovii,* in watermelon from Balogun market 5 (100.00 %); and *Listeria seegligeri* in garden egg (from Mile 12, 4, 21.05 %) and watermelon (from Lekki 6 (31.58 %) and Sabo-Ikorodu 9 (47.37 %) markets) possess virulence genes phosphatidylinositol- phospholipase C (*plcA and plcB* genes) used for attachment to the fresh fruit surfaces and virulence regulator (*prfA*). These genes form the foundation whereby *Listeria* strains grow and survive on fresh fruit (Table 7).

All the virulence genes in *L. monocytogenes* from tomatoes at Oyingbo market were listeriolysin O (*hlyA*) except *iniB* and actin (*actA* gene). *L. seegligeri* in watermelon from Lagos fruit had all the virulence genes, including *prs* gene (for survival, adaptation, and spread), proteins *clpE* (for virulence expressions), and Random Amplification of Polymorphic DNA (*RADP* gene) which initiate the regulator (*prfA* gene) for listeriosis infection. *Listeria seegligeri* from watermelon at Lekki and Sabo-Ikorodu markets confirmed the pathogenicity of causing listeriosis, which was also observed in other strains from other states (Table 7). A prevalence of 1 (33.33 %) was observed in all the virulence genes from garden egg and tomato samples at Osun State, including *prs* gene, except *plcA and plcB* genes. Only tomato samples from Owena market had *L. ivanovii* with 1 (16.67 %) each (from Ondo State). Meanwhile, two *L. seegligeri* from Iloro and Alade markets had each virulence gene to be 1 (50.00 %) or 1(100.00 %).

All the nine non-pathogenic *Listeria* strains had at least one virulence genes. Five *L. welshimeri* (n = 2, n = 3 and n = 1), two *L. innocua* (n = 0, n = 1 and n = 0) and eight *Listeria grayi* (n = 1, n = 1 and n = 0) were observed to carry at least one of the virulence genes in fruit from Lagos, Osun and Ondo States respectively (Table 8). This implies that highest number of non-pathogenic *Listeria* strains were found in fresh fruits from Osun State whereas only one *L. welshimeri* was observed in those from Ondo State (which have acquired all the virulence genes). The virulence genes in *L. welshimeri, L. innocua* and *L. grayii* from fruits at Ondo Lagos, Osun and Ondo States had incidence of 9 (56.25 %), 0 (0.00 %), and 7 (43.75 %); 18 (60.00 %), 8 (26.67 %) and 4 (13.33 %) as well as 9 (100.00 %), 0 (0.00 %) and 0 (0.00 %) respectively. Only *L. ivanovii, L. seegligeri* and *L. grayii* from fruits had significant difference of $p \geq 0.05$ in virulence genes profiling.

4. Discussion

Agboola and Bisi-Johnson (2023) highlighted that 90 % incidence of food poisoning is caused by bacteria which include *Listeria spp.* From this study, pathogenic and non-pathogenic *Listeria* strains were assessed and this concord to the research of Hasani et al. (2020) and Wurtzel et al. (2012). About, 2.22 % of *L. monocytogenes* was detected from marketed garden egg, tomato, and watermelon at Lagos, Osun and Ondo States, Nigeria which was quite low to the result from Olanbiwoninu et al.

Table 5
Specific antimicrobial resistant genes in pathogenic *Listeria* strains in specific fresh fruits from various markets.

Fruits	Garden Egg	Tomato	Watermelon	Fruits	Garden Egg	Tomato	Tomato	Tomato	Watermelon	Fruits	Garden Egg	Tomato	Watermelon	Watermelon	Fruits
Market	Balogun	Oyingbo				Ile-Epo	Agege	Mile-12	Balogun		Mile 12		Lekki	Sabo-Ikorodu	
Lagos	*Listeria monocytogenes*				*Listeria ivanovii*						*Listeria seegligeri*				
SHV	0 (0.00)	1 (100.00)	0 (0.00)	1 (6.67)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	1 (3.57)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
TEM,	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	1 (3.57)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
CTX	0 (0.00)	1 (100.00)	0 (0.00)	1 (6.67)	0 (0.00)	1 (25.00)	1 (25.00)	1 (25.00)	1 (25.00)	4 (14.29)	1 (50.00)	0 (0.00)	1 (50.00)	0 (0.00)	2 (9.09)
tetM	1 (50.00)	1 (50.00)	0 (0.00)	2 (13.33)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	1 (3.57)	0 (0.00)	0 (0.00)	1 (100.00)	0.00	1 (4.55)
gyrA	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	1 (3.57)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
gyrB	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	1 (3.57)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
NDM	1 (100.00)	0 (0.00)	0 (0.00)	1 (6.67)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	1 (3.57)	1 (33.33)	0 (0.00)	1 (33.33)	1 (33.33)	3 (13.64)
KPC	1 (100.00)	0 (0.00)	0 (0.00)	1 (6.67)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	1 (3.57)	1 (33.33)	0 (0.00)	1 (33.33)	1 (33.33)	3 (13.64)
IMP	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
$mefA_1$	1 (50.00)	1 (50.00)	0 (0.00)	2 (13.33)	0 (0.00)	1 (50.00)	0 (0.00)	0 (0.00)	1 (50.00)	2 (7.14)	1 (33.33)	0 (0.00)	1 (33.33)	1 (33.33)	3 (13.64)
$MsrA_1$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
$ereA_1$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	1 (3.57)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
$ermX_1$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
$mefA_2$	1 (100.00)	0 (0.00)	0 (0.00)	1 (6.67)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0.00	0 (0.00)
$MsrA_2$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
$ereA_2$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (3.57)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
$ermX_2$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
dfrA14	1 (50.00)	1 (50.00)	0 (0.00)	2 (13.33)	0 (0.00)	1 (50.00)	0 (0.00)	1 (50.00)	0 (0.00)	2 (7.14)	1 (50.00)	0 (0.00)	1 (50.00)	0 (0.00)	2 (9.09)
$Aad6_1$	1 (100.00)	0 (0.00)	0 (0.00)	1 (6.67)	0 (0.00)	0 (0.00)	1 (50.00)	1 (50.00)	0 (0.00)	2 (7.14)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (4.55)
$Aad6_2$	1 (50.00)	1 (50.00)	0 (0.00)	2 (13.33)	0 (0.00)	1 (25.00)	1 (25.00)	1 (25.00)	1 (25.00)	4 (14.29)	1 (50.00)	0 (0.00)	1 (50.00)	0 (0.00)	2 (9.09)
catA	1 (100.00)	0 (0.00)	0 (0.00)	1 (6.67)	0 (0.00)	1 (50.00)	0 (0.00)	1 (50.00)	0 (0.00)	2 (7.14)	0 (0.00)	0 (0.00)	1 (50.00)	1 (50.00)	2 (9.09)
vanA	0.00	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (3.57)	0.00	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
vanB	0.00	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (50.00)	1 (50.00)	2 (7.14)	1 (33.33)	0 (0.00)	1 (33.33)	1 (33.33)	3 (13.64)
ARG (Lagos)	9 (60.00)	6 (40.00)	0 (0.00)	15 (100.00)	0 (0.00)	6 (21.43)	8 (28.57)	7 (25.00)	7 (25.00)	28 (100.00)	7 (31.82)	0 (0.00)	10 (45.45)	5 (22.73)	22 (100.00)
ARG (*L. spp*)				15 (23.08)						28 (43.08)					22 (33.85)
Fruits	Garden Egg	Garden Egg	Tomato	Watermelon	Fruits	Garden Egg	Tomato	Watermelon	Fruits	Garden Egg	Tomato	Tomato	Watermelon	Fruits	
Market	Ifon Osun	Igbona	Ifon Osun								Orisunbare	Odori	Oja Ale, Iwo		
Osun	*Listeria monocytogenes*					*Listeria ivanovii*				*Listeria seegligeri*					
SHV	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
TEM,	1 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (7.69)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
CTX	1 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (7.69)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	1 (7.14)	
tetM	1 (50.00)	0 (0.00)	1 (50.00)	0 (0.00)	2 (15.38)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
gyrA	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
gyrB	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
NDM	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (7.69)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
KPC	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
IMP	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
$mefA_1$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	1 (7.14)	
$MsrA_1$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (7.14)	
$ereA_1$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
$ermX_1$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
$mefA_2$	1 (50.00)	1 (50.00)	0 (0.00)	0 (0.00)	2 (15.38)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (7.14)	
$MsrA_2$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
$ereA_2$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
$ermX_2$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
dfrA14	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (7.69)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (50.00)	0 (0.00)	1 (50.00)	2 (14.29)	
$Aad6_1$	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (7.69)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (50.00)	1 (50.00)	2 (14.29)	
$Aad6_2$	1 (50.00)	1 (50.00)	0 (0.00)	0 (0.00)	2 (15.38)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	1 (7.14)	
catA	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (33.33)	1 (33.33)	1 (33.33)	3 (21.43)	
vanA	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (7.69)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	1 (7.14)	
vanB	1 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (7.69)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (7.14)	
ARG (Osun)	6 (46.15)	2 (15.38)	5 (38.46)	0 (0.00)	13 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	5 (35.71)	5 (35.71)	4 (28.57)	14 (100.00)	

(*continued on next page*)

Table 5 (*continued*)

Fruits	Garden Egg	Tomato	Watermelon	Fruits	Garden Egg	Tomato	Tomato	Tomato	Watermelon	Fruits	Garden Egg	Tomato	Watermelon	Watermelon	Fruits
Market	Balogun	Oyingbo				Ile-Epo	Agege	Mile-12	Balogun		Mile 12		Lekki	Sabo-Ikorodu	
Lagos	*Listeria monocytogenes*				*Listeria ivanovii*						*Listeria seegligeri*				
					13 (48.15)				0 (0.00)					14 (51.85)	
Fruits	Garden Egg	Tomato	Watermelon	Fruits	Garden Egg	Tomato	Watermelon	Fruits	Garden Egg	Tomato	Tomato	Watermelon	Fruits		
Market						Owena				Iloro	Alade				
Ondo	*Listeria monocytogenes*				*Listeria ivanovii*				*Listeria seegligeri*						
SHV	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0.00	0 (0.00)	0 (0.00)		
TEM,	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)		
CTX	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)		
tetM	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (14.29)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	1 (6.25)		
gyrA	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (14.29)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)		
gyrB	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)		
NDM	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (14.29)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (6.25)		
KPC	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (6.25)		
IMP	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)		
$mefA_1$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (50.00)	1 (50.00)	0 (0.00)	2 (12.50)		
$MsrA_1$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (6.25)		
$ereA_1$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (50.00)	1 (50.00)	0 (0.00)	2 (12.50)		
$ermX_1$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)		
$mefA_2$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (50.00)	1 (50.00)	0 (0.00)	2 (12.50)		
$MsrA_2$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	1 (6.25)		
$ereA_2$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)		
$ermX_2$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)		
dfrA14	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (14.29)	0 (0.00)	1 (50.00)	1 (50.00)	0 (0.00)	2 (12.50)		
$Aad6_1$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (14.29)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)		
$Aad6_2$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)		
catA	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (14.29)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (6.25)		
vanA	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (14.29)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)		
vanB	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (50.00)	1 (50.00)	0 (0.00)	2 (12.50)		
ARG (Ondo)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	7 (100.00)	0 (0.00)	7 (100.00)	0 (0.00)	7 (43.75)	9 (56.25)	0 (0.00)	16 (100.00)		
ARG (Southwest)	15 (53.57)	8 (28.57)	5 (17.86)	28 (100.00)	13 (23.64)	13 (23.64)	8 (14.55)	14 (25.45)	7 (12.73)	55 (100.00)	21 (34.43)	5 (8.20)	30 (49.18)	5 (8.20)	61 (100.00)
ΣX^2	0.25	1.48	5.77	7.50	42.00	7.25	7.71	6.63	6.75	63.59	0.07	16.79	2.39	8.86	28.11
df	0	2	4		0	2	4	6	8		0	2	4	6	
p = 0.05	2.84	5.99	9.49		2.84	5.99	9.49	12.59	15.51		2.84	5.99	9.49	12.59	

Antimicrobial resistant genes (ARG) $mefA_1$, $MsrA_1$, $ereA_1$ and $ermX_1$ represent macrolides from Erythromycin; $mefA_2$, $MsrA_2$, $ereA_2$ and $ermX_2$ represent macrolides from azithromycin
ΣX_4^b Cumulative incidence of *Listeria* strain per Southwest sampling; Σx^2: Cumulative incidence of *Listeria* strain; *df*: Degrese of Freedom

Table 6
Specific antimicrobial resistant genes in non-pathogenic *Listeria* strains in specific fresh fruits from various market.

Fruits	Garden Egg	Tomato	Watermelon	Fruits	Garden Egg	Tomato	Watermelon	Fruits	Garden Egg	Tomato	Watermelon	Fruits	
Lagos Markets		Sabo-Ikorodu								Alaba			
Listeria spp	*Listeria welshimeri*				*Listeria innocua*				*Listeria grayi*				
SHV	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (14.29)	
TEM	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
CTX	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (14.29)	
tetM	0 (0.00)	1 (100.00)	0 (0.00)	1 (12.50)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
gyrA	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
gyrB	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
NDM	0 (0.00)	1 (100.00)	0 (0.00)	1 (12.50)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
KPC	0 (0.00)	1 (100.00)	0 (0.00)	1 (12.50)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
IMP	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
mefA$_1$	0 (0.00)	1 (100.00)	0 (0.00)	1 (12.50)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (14.29)	
MsrA$_1$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
ereA$_1$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
ermX$_1$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
mefA$_2$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
MsrA$_2$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
ereA$_2$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
ermX$_2$	0 (0.00)	1 (100.00)	0 (0.00)	1 (12.50)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
dfrA14	0 (0.00)	1 (100.00)	0 (0.00)	1 (12.50)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (14.29)	
Aad6$_1$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
Aad6$_2$	0 (0.00)	1 (100.00)	0 (0.00)	1 (12.50)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (14.29)	
catA	0 (0.00)	1 (100.00)	0 (0.00)	1 (12.50)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (14.29)	
vanA	0 (0.00)	0.00	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
vanB	0 (0.00)	0.00	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (14.29)	
ARG (Lagos)	0 (0.00)	8 (100.00)	0 (0.00)	8 (100.00) 8 (53.33)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	7 (100.00)	0 (0.00)	7 (100.00) 7 (46.67)	
Fruits	Garden Egg	Tomato	Watermelon	Watermelon	Fruits	Garden Egg	Tomato	Watermelon	Fruits	Garden Egg	Tomato	Watermelon	Fruits
Osun Markets		Oja-Ale Iwo	Igbona	Odori			Ota-Efun				Ilesha-Atamokunsa		
Listeria spp	*Listeria welshimeri*				*Listeria innocua*					*Listeria grayi*			
SHV	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
TEM,	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (8.33)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
CTX	0 (0.00)	0 (0.00)	1 (50.00)	1 (50.00)	2 (16.67)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
tetM	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	1 (8.33)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
gyrA	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	1 (8.33)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
gyrB	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
NDM	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
KPC	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
IMP	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
mefA$_1$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
MsrA$_1$	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (8.33)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
ereA$_1$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
ermX$_1$	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	1 (8.33)	0 (0.00)	1 (100.00)	0 (0.00)	1 (50.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
mefA$_2$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (50.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (100.00)
MsrA$_2$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
ereA$_2$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
ermX$_2$	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	1 (8.33)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
dfrA14	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	1 (8.33)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (100.00)
Aad6$_1$	0 (0.00)	0 (0.00)	1 (50.00)	1 (50.00)	2 (16.67)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
Aad6$_2$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
catA	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (8.33)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
vanA	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
vanB	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
ARG (Osun)	0 (0.00)	2 (16.67)	5 (41.67)	5 (41.67)	12 (100.00)	0 (0.00)	2 (100.00)	0 (0.00)	2 (100.00)	0 (0.00)	2 (100.00)	0 (0.00)	2 (100.00)

(*continued on next page*)

Table 6 (*continued*)

Fruits	Garden Egg	Tomato	Watermelon	Fruits	Garden Egg	Tomato	Watermelon	Fruits	Garden Egg	Tomato	Watermelon	Fruits	
Lagos Markets		Sabo-Ikorodu								Alaba			
Listeria spp	*Listeria welshimeri*				*Listeria innocua*				*Listeria grayi*				
					12 (75.00)				2 (12.50)				2 (12.50)
Fruits	Garden Egg	Tomato	Watermelon	Fruits	Garden Egg	Tomato	Watermelon	Fruits	Garden Egg	Tomato	Watermelon	Fruits	
Ondo Markets		Okitipupa											
Listeria spp	*Listeria welshimeri*				*Listeria innocua*				*Listeria grayi*				
SHV	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
TEM,	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
CTX	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
tetM	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
gyrA	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
gyrB	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
NDM	0 (0.00)	1 (100.00)	0 (0.00)	1 (25.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
KPC	0 (0.00)	1 (100.00)	0 (0.00)	1 (25.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
IMP	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
$mefA_1$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
$MsrA_1$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
$ereA_1$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
$ermX_1$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
$mefA_2$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
$MsrA_2$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
$ereA_2$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
$ermX_2$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
dfrA14	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
$Aad6_1$	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
$Aad6_2$	0 (0.00)	1 (100.00)	0 (0.00)	1 (25.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
catA	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
vanA	0 (0.00)	1 (100.00)	0 (0.00)	1 (25.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
vanB	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
ARG (Ondo)	0 (0.00)	4 (100.00)	0 (0.00)	4 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
ARG (Ondo)				4 (100.00)				0 (0.00)				0 (0.00)	
ARG (Southwest)	0 (0.00)	14 (73.68)	5 (26.32)	19 (100.00)	12 (85.71)	0 (0.00)	2 (14.29)	14 (100.00)	2 (18.18)	7 (63.64)	2 (18.18)	11 (100.00)	
ΣX^2	-	3.06	8.57	11.63	-	-	-	-	3.50	4.00	3.50	11.00	
df	0	2	4		0	2	4		0	2	4		
$p = 0.05$	2.84	5.99	9.49		2.84	5.99	9.49		2.84	5.99	9.49		

Antimicrobial resistant genes (ARG) $mefA_1$, $MsrA_1$, $ereA_1$ and $ermX_1$ represent macrolides from Erythromycin; $mefA_2$, $MsrA_2$, $ereA_2$ and $ermX_2$ represent macrolides from azithromycin
ΣX_4^b Cumulative incidence of *Listeria* strain per Southwest sampling; Σx^2: Cumulative incidence of *Listeria* strain; *df*: Degrese of Freedom

Table 7
Specific virulence genes in pathogenic *Listeria* strains in specific fresh fruits from various markets.

Fruits	Garden Egg	Tomato	Watermelon	Fruits	Garden Egg	Tomato	Watermelon	Fruits	Garden Egg	Tomato	Watermelon	Watermelon	Fruits	
Market	Balogun	Oyingbo					Balogun		Mile 12		Lekki	Sabo-Ikorodu		
Lagos	*Listeria monocytogenes*				*Listeria ivanovii*				*Listeria seegligeri*					
Prs	0 (0.00)	1 (100.00)	0 (0.00)	1 (8.33)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	1 (5.26)	
hlyA	0 (0.00)	1 (100.00)	0 (0.00)	1 (8.33)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (50.00)	1 (50.00)	2 (10.53)	
clpE	0 (0.00)	1 (100.00)	0 (0.00)	1 (8.33)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (50.00)	1 (50.00)	2 (10.53)	
plcA	1 (50.00)	1 (50.00)	0 (0.00)	2 (16.67)	0 (0.00)	0 (0.00)	1 (100.00)	1 (20.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	1 (5.26)	
plcB	1 (50.00)	1 (50.00)	0 (0.00)	2 (16.67)	0 (0.00)	0 (0.00)	1 (100.00)	1 (20.00)	1 (33.33)	0 (0.00)	1 (33.33)	1 (33.33)	3 (15.79)	
prfA	1 (50.00)	1 (50.00)	0 (0.00)	2 (16.67)	0 (0.00)	0 (0.00)	1 (100.00)	1 (20.00)	0 (0.00)	0 (0.00)	1 (50.00)	1 (50.00)	2 (10.53)	
InlB	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (33.33)	0 (0.00)	1 (33.33)	1 (33.33)	3 (15.79)	
actA	1 (100.00)	0 (0.00)	0 (0.00)	1 (8.33)	0 (0.00)	0 (0.00)	1 (100.00)	1 (20.00)	1 (33.33)	0 (0.00)	1 (33.33)	1 (33.33)	3 (15.79)	
RAPD	1 (50.00)	1 (50.00)	0 (0.00)	2 (16.67)	0 (0.00)	0 (0.00)	1 (100.00)	1 (20.00)	1 (50.00)	0 (0.00)	0 (0.00)	1 (50.00)	2 (10.53)	
VRG, X_1 (Lagos)	5 (41.67)	7 (58.33)	0 (0.00)	12 (100.00)	0 (0.00)	0 (0.00)	5 (100.00)	5 (100.00)	4 (21.05)	0 (0.00)	6 (31.58)	9 (47.37)	19 (100.00)	
VRG, X_1 (Lagos)				12 (33.33)				5 (13.89)					19 (52.78)	
Fruits	Garden Egg	Garden Egg	Tomato	Watermelon	Fruits	Garden Egg	Tomato	Watermelon	Fruits	Garden Egg	Tomato	Tomato	Watermelon	Fruits
Market	Igbona	Ifon-Osun	Ifon-Osun								Orisunbare	Odori	Oja-Ale iwo	
Osun	*Listeria monocytogenes*					*Listeria ivanovii*				*Listeria seegligeri*				
Prs	1 (33.33)	1 (33.33)	1 (33.33)	0 (0.00)	3 (14.29)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (50.00)	1 (50.00)	0 (0.00)	2 (11.76)
hlyA	1 (33.33)	1 (33.33)	1 (33.33)	0 (0.00)	3 (14.29)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (50.00)	1 (50.00)	0 (0.00)	2 (11.76)
clpE	1 (33.33)	1 (33.33)	1 (33.33)	0 (0.00)	3 (14.29)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	1 (5.88)
plcA	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (50.00)	1 (50.00)	0 (0.00)	2 (11.76)
plcB	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (33.33)	1 (33.33)	1 (33.33)	3 (17.65)
prfA	1 (33.33)	1 (33.33)	1 (33.33)	0 (0.00)	3 (14.29)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (50.00)	1 (50.00)	2 (11.76)
InlB	1 (33.33)	1 (33.33)	1 (33.33)	0 (0.00)	3 (14.29)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (5.88)
actA	1 (33.33)	1 (33.33)	1 (33.33)	0 (0.00)	3 (14.29)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (33.33)	1 (33.33)	1 (33.33)	3 (17.65)
RAPD	1 (33.33)	1 (33.33)	1 (33.33)	0 (0.00)	3 (14.29)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	1 (5.88)
VRG, X_2 (Osun)	7 (33.33)	7 (33.33)	7 (33.33)	0 (0.00)	21 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	6(35.29)	7 (41.18)	4 (23.53)	17 (100.00)
VRG, X_2 (Osun)					21 (55.26)				0 (0.00)					17 (44.74)
Fruits	Garden Egg	Tomato	Watermelon	Fruits	Garden Egg	Tomato	Watermelon	Fruits	Garden Egg	Tomato	Tomato	Watermelon	Fruits	
Market						Owena				Iloro	Alade			
Ondo	*Listeria monocytogenes*				*Listeria ivanovii*				*Listeria seegligeri*					
Prs	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (50.00)	1 (50.00)	0 (0.00)	2 (15.38)	
hlyA	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	1 (7.69)	
clpE	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	1 (7.69)	
plcA	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (16.67)	0 (0.00)	1 (100.00)	0 (0.00)	0 (0.00)	1 (7.69)	
plcB	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (16.67)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (7.69)	
prfA	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (16.67)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (7.69)	
InlB	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (16.67)	0 (0.00)	1 (50.00)	1 (50.00)	0 (0.00)	2 (15.38)	
actA	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (16.67)	0 (0.00)	1 (50.00)	1 (50.00)	0 (0.00)	2 (15.38)	
RAPD	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (16.67)	0 (0.00)	1 (50.00)	1 (50.00)	0 (0.00)	2 (15.38)	
VRG, X_3 (Ondo)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	6 (100.00)	0 (0.00)	6 (100.00)	0 (0.00)	7 (53.85)	6 (46.15)	0 (0.00)	13 (100.00)	
VRG, X_3 (Ondo)				0 (0.00)				6 (31.58)					13 (68.42)	
ΣX	12 (36.36)	14 (42.42)	7 (21.21)	33 (100.00)	21 (65.63)	6 (18.75)	5 (15.63)	32 (100.00)	4 (8.70)	7 (15.22)	18 (39.13)	16 (34.78)	46 (100.00)	12 (36.36)
ΣX^2	0.15	1.13	4.00	5.27	11.00	26.00	27.00	64.00	5.68	17.77	0.49	6.32	30.26	ΣX^2
df	0	2	4		0	2	4		0	2	4	6		df
p = 0.05	2.84	5.99	9.49		2.84	5.99	9.49		2.84	5.99	9.49	12.59		p = 0.05

ΣX_4^b Cumulative incidence of *Listeria* strain per Southwest sampling; Σx^2: Cumulative incidence of *Listeria* strain; *df*: Degrese of Freedom

Table 8
Specific virulence genes in non-pathogenic *Listeria* strains in specific freshfruits from various markets.

Fruits	Garden Egg	Tomato	Watermelon	Fruits	Garden Egg	Tomato	Watermelon	Fruits	Garden Egg	Tomato	Watermelon	Fruits	
Lagos Markets		Sabo-Ikorodu		Oyingbo						Alaba			
Listeria spp	*Listeria welshimeri*				*Listeria innocua*				*Listeria grayi*				
Prs	0 (0.00)	1 (100.00)	0 (0.00)	1 (11.11)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
hlyA	0 (0.00)	1 (100.00)	0 (0.00)	1 (11.11)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (14.29)	
clpE	0 (0.00)	1 (100.00)	0 (0.00)	1 (11.11)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (14.29)	
plcA	0 (0.00)	1 (100.00)	0 (0.00)	1 (11.11)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (14.29)	
plcB	0 (0.00)	1 (100.00)	0 (0.00)	1 (11.11)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (14.29)	
prfA	0 (0.00)	1 (100.00)	0 (0.00)	1 (11.11)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (14.29)	
InlB	0 (0.00)	1 (100.00)	0 (0.00)	1 (11.11)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (14.29)	
actA	0 (0.00)	1 (100.00)	0 (0.00)	1 (11.11)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
RAPD	0 (0.00)	1 (100.00)	0 (0.00)	1 (11.11)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (14.29)	
VRG (Lagos)	0 (0.00)	9 (100.00)	0 (0.00)	9 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	7 (100.00)	0 (0.00)	7 (100.00)	
VRG (Lagos)				9 (56.25)				0 (0.00)				7 (43.75)	
Fruits	Garden Egg	Tomato	Watermelon	Watermelon	Fruits	Garden Egg	Tomato	Watermelon	Fruits	Garden Egg	Tomato	Watermelon	Fruits
Osun Markets		Oja-Ale Iwo	Igbona	Odori			Ota-Efun				Ilesha-Atamokunsa		
Listeria spp	*Listeria welshimeri*					*Listeria innocua*				*Listeria grayi*			
Prs	0 (0.00)	0 (0.00)	1 (50.00)	1 (50.00)	2 (11.11)	0 (0.00)	1 (100.00)	0 (0.00)	1 (12.50)	0 (0.00)	1 (100.00)	0 (0.00)	1 (25.00)
hlyA	0 (0.00)	0 (0.00)	1 (50.00)	1 (50.00)	2 (11.11)	0 (0.00)	1 (100.00)	0 (0.00)	1 (12.50)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
clpE	0 (0.00)	0 (0.00)	1 (100.00)	0 (0.00)	1 (5.56)	0 (0.00)	1 (100.00)	0 (0.00)	1 (12.50)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
plcA	0 (0.00)	0 (0.00)	0 (0.00)	1 (100.00)	1 (5.56)	0 (0.00)	1 (100.00)	0 (0.00)	1 (12.50)	0 (0.00)	1 (100.00)	0 (0.00)	1 (25.00)
plcB	0 (0.00)	1 (50.00)	0 (0.00)	1 (50.00)	2 (11.11)	0 (0.00)	1 (100.00)	0 (0.00)	1 (12.50)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
prfA	0 (0.00)	1 (33.33)	1 (33.33)	1 (33.33)	3 (11.11)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
InlB	0 (0.00)	0 (0.00)	1 (50.00)	1 (50.00)	2 (11.11)	0 (0.00)	1 (100.00)	0 (0.00)	1 (12.50)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)
actA	0 (0.00)	1 (33.33)	1 (33.33)	1 (33.33)	3 (11.11)	0 (0.00)	1 (100.00)	0 (0.00)	1 (12.50)	0 (0.00)	1 (100.00)	0 (0.00)	1 (25.00)
RAPD	0 (0.00)	1 (50.00)	1 (50.00)	0 (0.00)	2 (11.11)	0 (0.00)	1 (100.00)	0 (0.00)	1 (12.50)	0 (0.00)	1 (100.00)	0 (0.00)	1 (25.00)
VRG (Osun)	0 (0.00)	4 (22.22)	7 (38.89)	7 (38.89)	18 (100.00)	0 (0.00)	8 (100.00)	0 (0.00)	8 (100.00)	0 (0.00)	4 (100.00)	0 (0.00)	4 (100.00)
VRG (Osun)					18 (60.00)			0 (0.00)	8 (26.67)				4 (13.33)
Fruits	Garden Egg	Tomato	Watermelon	Fruits	Garden Egg	Tomato	Watermelon	Fruits	Garden Egg	Tomato	Watermelon	Fruits	
Ondo Markets		Okitipupa											
Listeria spp	*Listeria welshimeri*				*Listeria innocua*				*Listeria grayi*				
Prs	0 (0.00)	1 (100.00)	0 (0.00)	1 (11.11)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
hlyA	0 (0.00)	1 (100.00)	0 (0.00)	1 (11.11)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
clpE	0 (0.00)	1 (100.00)	0 (0.00)	1 (11.11)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
plcA	0 (0.00)	1 (100.00)	0 (0.00)	1 (11.11)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
plcB	0 (0.00)	1 (100.00)	0 (0.00)	1 (11.11)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
prfA	0 (0.00)	1 (100.00)	0 (0.00)	1 (11.11)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
InlB	0 (0.00)	1 (100.00)	0 (0.00)	1 (11.11)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
actA	0 (0.00)	1 (100.00)	0 (0.00)	1 (11.11)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
RAPD	0 (0.00)	1 (100.00)	0 (0.00)	1 (11.11)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
VRG (Ondo)	0 (0.00)	9 (100.00)	0 (0.00)	9 (100.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	
VRG (Ondo)				9 (100.00)				0 (0.00)				0 (0.00)	
VRG (Southwest)	0 (0.00)	22 (70.97)	7 (22.58)	31 (100.00)	18 (69.23)	0 (0.00)	8 (30.77)	26 (100.00)	8 (30.77)	7 (26.92)	4 (15.38)	7 (26.92)	26 (100.00)
ΣX^2	-	5.10	9.69	14.79	-	-	-	-	9.33	6.00	4.67	20.00	ΣX^2
df	0	2	4		0	2	4		0	2	4		df
p = 0.05	2.84	5.99	9.49		2.84	5.99	9.49		2.84	5.99	9.49		p = 0.05

ΣX_4^b Cumulative incidence of *Listeria* strain per Southwest sampling; Σx^2: Cumulative incidence of *Listeria* strain; *df*: Degree of Freedom

(2024b) with 3.77 % of *L. monocytogenes* from cucumber, tomato, watermelon and garden egg on retails and at home garden from Oyo, Ogun and Ekiti States, Nigeria. The highest prevalence of pathogenic and non-pathogenic *Listeria* strains was observed in fruits from Ile-Epo (Lagos State) and Okitipupa (Ondo State) respectively because of variance in microbial community and geographical zones. This was highlighted by Abriouel et al. (2017). Incidence and dispersion in fresh fruits were era, type, and location-based. Agricultural, hygienic handling practices, food, and non-food surface contacts result in continuous contamination along the supply chain. Accumulation of wastes of previously harvested or sold fruits predisposes new ones to *Listeria* contamination. Contaminated humans, livestock, reptiles, rodents, amphibians or wild animals could be effective contaminants. The spread of *L. monocytogenes* 6 (21.43 %) in fruits, observed from this work, was higher than that studied by Ajayeoba et al. (2015). Agboola and Bisi-Johnson (2023) recovered 20 % prevalence from leafy vegetables and irrigation water in both dry and wet seasons from Osun East, Osun West, and Osun Central in Osun State and this has significant difference compared to the 24.00 % gotten in this research work.

The outcome of *Listeria* strains in each fruit and vegetable was of higher prevalence when compared to the report of Ieren et al. (2013) and Bamidele et al. (2017). A lot of fresh produce is loss to spoilage due to poor storage and long-distant transporting in poor conditions, with lack or inadequate facilities (especially cold storage facilities) and technological know-how. More so, with the interaction between a contaminated environment and bruised harvested fresh produce, *Listeria spp* speedily wastes fresh produce. However, at the market level, unhygienic conditions of fresh fruits contribute to the crisis of food spoilage and poisoning. This is more reason for the geometric mean above 100 MPN/g in *L. spp* in fruits from Igbona, Odori, Okitipupa, and Oja-Ale markets. Although, none of the microbial counts of *L. monocytogenes,* from this study, were found to be above 100 cfu/g. Food Agriculture Organisation and World Health Organization (2024) considered food with upshot microbial count of 100 cfu *L. monocytogenes* to be withdrawn from market. Outcome of *L. monocytogenes* in this study, could be from contamination with farm soil, irrigation (with waste water, river, runoff water) and planting (with animal waste amending soil), market soil and sunny-storage displayed marketed fruits predispose fruits to *Listeria* strains Bougnom et al. (2019), Chigor et al. (2020), Akinde et al. (2016). This is correlated to the report by Ewah (2013) also.

The highest prevalence of antimicrobial resistance gene (ARG) found in *L. monocytogenes, L. ivanovii* and *L. seegligeri* in Lagos state was contrary to the result gotten by Holvoet et al. (2013). Golly et al. (2016) and Brun et al. (2022) reported ARG in *Listeria* isolates which resulted from contaminated manure fertilizer, root crops, vegetables, pulses and grains, culinary herbs, salad crops, raw or improperly composted manure. Collecting containers/sacks, harvester and equipment, and handlers' hands could be a source of *Listeria* strains. The strains were carbapenem, chloramphenicol, macrolides, tetracycline, and folate resistant, subsequent from marshy contaminated soil (during the wet season) and where fresh produce was offloaded and jam-packed without safety consciousness. Poor post-harvest processing in the market, including cutting, washing or sanitizing, transporting, packaging or storing and the reuse of wash water could contribute to the higher resistant *Listeria* strains in fresh fruits. The dusty market environment with flour, pepper, and dust fro the crowd in the market could be a source of the ubiquitous strains.

Tomato from Lagos Sabo-Ikorodu and Alaba markets had *L. welshimeri* (*tetM, NDM, KPC, mefA*$_1$*, ermX1, dfrA14, Aad6*$_2$, and *catA*) and *L. grayi* (*SHV*, *CTX*, *mefA*$_1$, *dfrA14*, *Aad6*, *catA* and *vanB*) due to contamination and acquiring of genes by bacteria via overcrowded, marshy; dirty-spoilt stacked markets; unhygienic handlers (farmers, transporters, vendors, buyers, and other marketers); and dirty packing tools/equipment display ground; unavailability of cold storage facility; and cross-contamination with infected food and non-food surfaces in market (Qadri et al., 2015; Moreira et al., 2023).

The presence of Extended-Spectrum beta-Lactamase Producing (ESBL) (*SHV*, *TEM* and *CTX* genes) in this study was contrary to Oyeyipo et al. (2022), Sapkota et al. (2019) and Moussé et al. (2015), who discovered the genes in gram-negative bacteria. However, Zakrzewski et al. (2020) detected more ESBL (TEM, SHV and CTX-M) genes in gram-positive bacteria (*Staphylococcus aureus* 6 (18.00 %) and *S. haemolyticus* 25 (74 %.00)) than in gram-negative bacteria (*Klesiella spp* and *Escherichia coli*) from 150 women who went through cesarean delivery in Al-Basrah Teaching Hospital.

Pathogenic and non-pathogenic *Listeria* strains with multiple virulence genes in fruits from various sampling locations could be routed from contaminated water, air, and handlers. This study discovered *hlyA* gene from non-pathogenic strains which concur to Ibrahim et al. (2021), who discovered listeriolysin, *hlyA* gene in non-pathogenic *L. innocua* isolated from fish and shrimps. Cross-contamination with bacteria that had acquired this gene from refreshing and deep-washing water used by market vendors; and from unhygienic market ground, buyers, as well as displayed containers.

5. Conclusion

Listeria monocytogenes, L. ivanovii, L. seegligeri, *L. welshimeri, L. grayi* and *L. innocua* could thereby contaminate garden eggs, tomato, and watermelon. The geometric mean above 100 MPN/g in *Listeria spp* from fruits at Igbona, Odori, Okitipupa, and Oja-Ale markets showed that they were unfit for consumption. *Listeria* strains from this study were carbapenem, chloramphenicol, macrolides, tetracycline, and folate resistant with the highest prevalence found in fruit samples from Balogun, Agege, and Lekki in Lagos state. Nevertheless, *Listeria grayi* and *L. monocytogenes* were with acquired *SHV* and *CTX* genes, which is rare. *Listeria monocytogenes* in garden egg samples from Osun State had a high incidence rate of *TEM*, *tetM*, *mefA*$_2$, *Aad6*$_2$ and *vanB* genes, whereas *L. monocytogenes* in tomato from the Oyingbo market and *L. seegligeri* in watermelon from the Lekki and Sabo-Ikorodu markets had all the virulence genes. Both virulent-resistant pathogenic and non-pathogen *Listeria* strains could cause reoccurring listeriosis in consumers and regular spoilage of fruit. Moreso, a higher virulence gene frequency rate was found in *L. monocytogenes* from fresh fruit in Osun state and the decreasing trend was observed in other isolates from other states. Thus, pathogenic and non-pathogen *Listeria* strains in this study, were capable to attach to fruit surfaces. The pathogenic *Listeria* strains could acquire these genes from non-pathogenic species, regulate them to infection. Therefore, good and healthy handling of fruits from farm to market level is crucial because constant listeriosis in consumers could lead to an outbreak while regular spoilage via contact contamination results to timely wastage.

The virulence and antimicrobial resistance gene profiling was only at PCR-electrophoresis phase, there is need for further studies which will investigate these genes at sequencing level. Other recent and advanced researches as reported by FAO/WHO MRA38 report on *L. monocytogenes* are thereby recommended for further analysis.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Esther Omobola Areo reports financial support was provided by Hansataj Nigeria Limited, Lagos, Nigeria. Esther Omobola Areo reports financial support was provided by Riocharistos Engineering Limited, Lagos, Nigeria. Esther Omobola Areo reports financial support was provided by Shenkeve Engineering and Procurement Limited, Lagos, Nigeria. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.microb.2025.100286.

Data availability

No data was used for the research described in the article.

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