RESEARCH ARTICLE

Prevalence and Multidrug Resistance Indices of *Listeria* spp. from Bovine Milk, Milk Products and Clinical Samples in and around Junagadh City, Gujarat, India

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Abstract

The antibiotic resistance profiles of 18 *Listeria* spp. (5.14%) obtained from a total of 350 (100 bovine milk, 100 milk products and 150 animal clinical) samples were evaluated using the agar disc diffusion method against 14 commonly used antibiotics in human and veterinary medicine. All 18 *Listeria* isolates exhibited varying levels of resistance to the tested antibiotics. Notably, resistance observed in all isolates (100%) against ampicillin, amoxyclav and oxacillin is particularly alarming, as ampicillin remains the primary drug of choice for *L. monocytogenes* infections, suggesting the potential emergence of multi-drug resistant (MDR) strains. Additionally, 77.77% of the isolates (14 out of 18) showed resistance to chloramphenicol and cefepime, while 55.55% (10 isolates) were resistant to gentamicin, which further underscores the reduced efficacy of commonly used antibiotics. The isolates showing resistance to three or more antibiotics were evaluated for the multiple antibiotic-resistant phenotypes (MARPs) and multiple antibiotic resistance (MAR) index. Thirteen *L. monocytogenes* isolates exhibited 12 MARP patterns with sistance to 7-13 antibiotics (MAR index: 0.50-0.92), while five other *Listeria* spp. (2 *L. innocua*, 0.57%; 3 *L. seeligeri*, 0.85%) showed 5 patterns resistant to 8-13 antibiotics with MAR index 0.35-0.71, suggesting urgent need for stringent monitoring, judicious antibiotic use, and improved food safety measures to prevent the spread of resistant *Listeria* strains.

Key words: Bovine milk, *Listeria monocytogens*, MDR strains, Multiple antibiotic resistance (MAR) index, MAR phenotypes.

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Introduction

Foodborne infections remain a major public health challenge worldwide, with *Listeria monocytogenes* as a highly virulent foodborne pathogen with a human case fatality rate of 20-30% (Choi *et al*., 2018). Alongside *L. ivanovii*, it is one of only two pathogenic species, with the former affecting both humans and animals. Its persistence in the food chain is due to stress tolerance, growth at refrigeration temperatures, and biofilm formation, making eradication from food-processing environments difficult (Byun *et al*., 2022). Contamination occurs in meat, fish, dairy, vegetables, and ready-to-eat foods, with transmission mainly via ingestion (Wang *et al*., 2021). In humans, listeriosis causes septicaemia, meningitis, or gastroenteritis (Maurella *et al*., 2018), while in animals it leads to encephalitis, septicaemia, abortion, and mastitis most notably "circling disease" in ruminants (Esposito *et al*., 2021).

The therapeutic management of listeriosis relies on antibiotics with gentamicin in combination with beta-lactams such as ampicillin or penicillin, but reports of antimicrobial resistance (AMR) in *L. monocytogenes* have been rising since the first cases in 1988 (Wu *et al*., 2021). Resistance to clinically important antibiotics, including multidrug resistance, threatens both human and veterinary health (Mpundu *et al*., 2021). This underscores the need for continuous monitoring of resistant strains to protect food safety and therapeutic efficacy. The present study investigated the prevalence and multidrug resistance indices of *Listeria* spp. from bovine milk, dairy products, and clinical samples around Junagadh, Gujarat, India.

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Materials and Methods

A total of 350 samples were obtained from dairy farms, retailers, and vendors who were chosen randomly. These included 100 bovine milk samples (50 each cattle & buffalo), 25 samples each of cheese, ice cream, curd, and fruit salad. Besides these, 50 each mastitic milk, fecal sample, and vaginal swab samples were obtained from unorganized dairy farms in and around Junagadh city and Veterinary Clinical Complex of Veterinary College, Junagadh (Gujarat, India). All samples were taken under standard microbiological conditions using properly labelled with date, location, and other details in sterile sample-collecting containers. The samples were then transported to the laboratory for microbiological examination and stored within a chillier thermoflask.

Isolation/Identification of *Listeria* spp. and *In Vitro* Antimicrobial Susceptibility Profile

This research employed the protocol developed by Barbuddhe *et al.* (2014), which was based on the USDA-FSIS method with specific modifications to maximize the process, to recover *Listeria* spp. from a range of samples.

Disc diffusion method of Bauer *et al.* (1966) was followed to determine the antibiotic susceptibility of *Listeria* isolates using 14 different commonly used antibiotics. According to the manufacturer's guidelines, the diameter of the zone of inhibition around each disc was measured to determine each isolate's sensitivity or resistance pattern.

Assessing Multiple Antibiotic Resistance Phenotypes and MAR index

Listeria spp. isolates that were resistant to three or more antibiotics were screened for multiple antibiotic-resistant phenotypes (MARPs) by the method of Iwu and Okoh (2020). The multiple antibiotic resistance (MAR) index of the isolates was calculated using the formula: MAR index = a/b, where "a" represents the number of antibiotics to which the isolate is resistant, and "b" represents the total number of antibiotics tested (Krumpermans, 1983).

Results and Discussion

Prevalence of *Listeria* spp.

Eighteen out of 350 (5.14%) samples, ranging from milk, milk products, and clinical specimens, were positive for various *Listeria* species. Among these, two samples (0.57%) represented *L. innocua*, three samples (0.85%) represented *L. seeligeri*, and thirteen samples (3.71%) represented *L. monocytogenes* (Table 1).

Overall prevalence of *Listeria* spp. in the present study (5.14%) was in good confirmity with the findings (6.56% and 6.75%) of Sarangi *et al.* (2009) and Hassen *et al.* (2025), while other studies (Jamali *et al.,* 2015) reported much higher rates of prevalence (32.5%). Conversely, prevalence was 2.7% observed by Suryawanshi *et al.* (2023).

The 6.0% occurrence of *L. monocytogenes* in raw milk found was consistent with report of Biswas *et al.* (2018). Kayode and Okoh (2022) documented 40% occurrence rates of *L. monocytogenes*. Contrarily, Suryawanshi *et al.* (2023), and Hassen *et al.* (2025) found *L. monocytogenes* with the prevalence of 1.14% and 5.8%, pointing towards the heterogeneity of *Listeria* contamination in various studies.

The prevalence of 2% for *L. innocua* in raw milk found in this study concurred with other studies (Sarangi *et al.,* 2009), while higher prevalence rate 12.7% was found by Tahoun *et al.* (2017). Conversely, Hassen *et al.* (2025) reported a quite low prevalence of 0.9%. The occurrence of 2.0% *L. seeligeri* noted in raw milk was higher than 0.1% and 1.04% recorded by Borena *et al.* (2022) and Hassen *et al.* (2025).

Antibiogram Profile of the *Listeria* Isolates

All 18 of the *Listeria* isolates in this study exhibited different levels of resistance to antibiotics (Table 2). As ampicillin remains the preferred drug of choice for treatment of infections due to *L. monocytogenes*, the observation that all isolates (100%) were resistant to ampicillin, amoxyclav, and oxacillin is particularly alarming and creates the likelihood of the development of multi-drug resistant (MDR) strains. The presence of 55.55% (10/18 isolates) resistant to gentamicin and 77.77% (14/18) to cefepime and chloramphenicol further confers the reduced efficacy of the widely used antibiotics. 27.77% (5/18) of the isolates exhibited resistance to ciprofloxacin, linezolid, and clindamycin. Also, Table 2 indicates that 4 isolates (22.22%) were tetracycline-resistant, 3 isolates (16.66%) were erythromycin-resistant, and 2 isolates (11.11%) were rifampicin-resistant. These results indicate varying degrees of acquired resistance mechanisms among the *Listeria* isolates, which can be influenced by the inappropriate use of antibiotics in clinical settings, food production, or agriculture. These findings suggest the necessity for persistent monitoring, antimicrobial stewardship, and other treatment strategies for the prevention of drug-resistant *Listeria* infections and

Table 1: Prevalence of *Listeria* spp. from milk, milk products, and clinical bovine specimens

Type of sample	Sample analyzed	Positive samples	Positive sample for Listeria spp. (%)			Overall prevalence
			L. monocytogenes	*L. innocua*	*L. seeligeri*	
Bovine milk	100	10 (10%)	6 (6.0%)	2 (2.0%)	2 (2.0%)	
Milk products	100	5 (5%)	4 (4.0%)	0	1 (1.0%)	**5.14%**
Clinical samples	150	3 (2%)	3 (2.0%)	0	0	
Total	**350**	**18 (5.14%)**	**13 (3.71%)**	**2 (0.57%)**	**3 (0.85%)**	

public health protection since they align with global reports of escalating AMR among *Listeria* spp.

Most of the *Listeria* spp. isolates, such as *L. monocytogenes*, showing 100% resistant to ampicillin in this study, concurred well with Mohamed *et al.* (2022), who reported resistance of *Listeria* spp. to ampicillin up to 93%. Swetha *et al*. (2021) reported 100% resistance of *Listeria* spp. to rifampicin, higher than the present study, while Elavarasi *et al*. (2023) found 91.7% resistance. In contrast, Aksoy *et al*. (2018) observed complete sensitivity. For chloramphenicol, the 77.77% resistance observed here was much higher than 16.66% reported by Sonar (2010).

In this study, *Listeria* spp. overall showed 55.55% sensitivity to erythromycin, lower than 83.33% reported by Sonar (2010), but comparable to Jamali *et al*. (2015) with 16.66% resistance. Doxycycline sensitivity of *L. monocytogenes* (100%) was consistent with Warke (2022), who also reported 100% sensitivity in *L. monocytogenes*, whereas Abdeen *et al*. (2021) reported higher resistance (64.4%). Gentamicin sensitivity of overall *Listeria* spp. was only 5.55%, markedly lower than 52-58% recorded by Sonar (2010) and Jamali *et al*. (2015). *Listeria* isolates in this study were less sensitive to ciprofloxacin than that (83.33%) reported by Sonar (2010), though resistance was lower than the several studies and comparable to Abdeen *et al*. (2021) (29.4%). Linezolid resistance aligned with Elavarasi *et al*. (2023) (44%), while sensitivity level reported by Malakar *et al*. (2020) (38.46%) was consistent with the present study.

In this study, *Listeria* isolates in general showed 22.22% resistance and 38.88% sensitivity to tetracycline, lower than complete sensitivity reported by Warke *et al*. (2019), but within the 25-70% sensitivity range noted by others. Resistance rate was reported higher than the Jamali *et al*. (2015) in present study, and clindamycin sensitivity was 69.23%, that is below 90-100% recorded by Zeinali *et al*. (2017) and Biswas *et al*. (2018), but higher than that of 41.66% recorded by Sonar (2010). Clindamycin resistance (15.38%) in this study was lower than 25% noted by Sonar (2010). Sensitivity to meropenem was lower than reports of total sensitivity by Sambyal *et al*. (2017) and Shourav *et al*. (2020). No isolates were sensitive to amoxiclav. All isolates were resistant to oxacillin, consistent with Borena *et al*. (2022) and Mohamed *et al*. (2022), but contradicted Shourav *et al*. (2020), who reported full sensitivity. In the current study, out of total 18 *Listeria* isolates majority were *L. monocytogenes,* and therefore the pattern of sensitivity/resistance to different antibiotics tested remain same for overall isolates as well as *L. monocytogenes,* whereas the isolates of *L. innocua* and *L. seeligeri* were only 2 and 3, hence their sensitivity pattern was of least significance.

MAR Phenotypes and MAR Index

Tables 3 and 4 list details of the MARPs and MAR indices for *L. monocytogenes* and other *Listeria* species isolated from dairy food, animal clinical specimens, and bovine milk, respectively. Thirteen *L. monocytogenes* strains in this study were resistant to 7-13 antibiotics by exhibiting 12 different MARP patterns. Their MAR indices ranged from 0.50 to 0.92. The five *Listeria* spp. isolates had five different MARP patterns, with MAR indices between 0.35 and 0.71 and resistance to 8-13 antibiotics. Isolates of intermediate resistance were counted as resistant for MAR index

Table 2: Sensitivity (S) and resistance (R) pattern of *Listeri*a spp. isolated from milk, milk products, and clinical bovine specimens

Sr. No.	Antimicrobial discs	Overall *Listeria* spp. (n=18)		*L. monocytogenes* (n=13)		*L. innocua* (n=2)		*L. seeligeri* (n=3)	
		S (%)	R (%)	S (%)	R (%)	S (%)	R (%)	S (%)	R (%)
1.	Ampicillin (AMP)	0	18 (100)	0 (0)	13 (100)	0 (0)	2 (100)	0 (0)	3 (100)
2.	Rifampicin (RIF)	14 (77.77)	2 (11.11)	11(84.61)	0 (0)	1 (50.0)	0 (0)	2 (66.66)	1 (33.33)
3.	Chloramphenicol (C)	0	14(77.77)	0 (0)	10 (76.92)	0 (0)	2 (100)	0 (0)	2 (66.66)
4.	Erythromycin (E)	10 (55.55)	3 (16.66)	7 (53.84)	3 (23.07)	1 (50.0)	0 (0)	2 (66.66)	0 (0)
5.	Cefepime (CPM)	0	14 (77.77)	0 (0)	10 (76.92)	0 (0)	2 (100)	0 (0)	2 (66.66)
6.	Doxycycline (DO)	18 (100)	0	13 (100)	0 (0)	2 (100)	0 (0)	3 (100)	0 (0)
7.	Gentamicin (GEN)	1 (5.55)	10 (55.55)	1 (7.69)	6 (46.15)	0 (0)	2 (100)	0 (0)	2 (66.66)
8.	Ciprofloxacin (CIP)	7 (38.88)	5 (27.77)	5 (38.46)	4 (30.76)	1 (50.0)	0 (0)	1 (33.33)	1 (33.33)
9.	Linezolid (LZ)	6 (33.33)	5 (27.77)	5 (38.46)	2 (15.38)	0 (0)	2 (100)	1 (33.33)	1 (33.33)
10.	Tetracycline (TE)	7 (38.88)	4 (22.22)	7 (53.84)	2 (15.38)	0 (0)	1 (50)	0 (0)	1 (33.33)
11.	Clindamycin (CD)	11 (61.11)	5 (27.77)	9 (69.23)	2 (15.38)	1 (50.0)	1 (50)	1 (33.33)	2 (66.66)
12.	Meropenem (MRP)	16 (88.88)	0	12 (92.30)	0 (0)	2 (100)	0 (0)	2 (66.66)	0 (0)
13.	Amoxyclav (AMC)	0	18 (100)	0 (0)	13 (100)	0 (0)	2 (100)	0 (0)	3 (100)
14.	Oxacillin (OX)	0	18 (100)	0 (0)	13 (100)	0 (0)	2 (100	0 (0)	3 (100)

calculation purposes. As per Maurice *et al.* (2018), isolates from risky settings that involve high antibiotic exposure are more likely to possess a MAR index of more than 0.2, whereas those from sources involving comparatively lower risks and limited antibiotic usage are implied by MAR index values below 0.2.

Several studies have reported high MAR indices in *L. monocytogenes*, indicating significant antibiotic exposure. Iwu and Okoh (2020) observed MAR indices of 0.2-0.8, while Marian *et al*. (2012) and Wong *et al*. (2012) found values above 0.2 in most isolates, linking them to high-risk sources. Matyar *et al*. (2010) reported MAR indices of 0.23-0.38 in foodborne isolates, with resistance to multiple antibiotics. Similarly, Usman *et al*. (2016) found 88.9% of dairy isolates had MAR indices >0.2, some as high as 0.9, confirming widespread multidrug resistance in food and environmental sources.

The MAR index analysis values above 0.2 indicated high-risk sources with heavy antibiotic exposure (Krumperman, 1983). All 18 *Listeria* isolates in this study had MAR indices >0.2, suggesting their origin from environments with extensive antibiotic use and supporting the survival of multidrug-resistant strains. These findings highlight the threat of antibiotic-resistant *Listeria* in milk, dairy products, and animal clinical samples, stressing the need for strict antibiotic stewardship and surveillance to prevent their spread through the food chain.

Conclusion

The findings of current study revealed the prevalence of *Listeria* spp., to the extent of 5.14% (18/350) in bovine milk, milk products and clinical samples. The isolation of multidrug-resistant *Listeria* spp., particularly *L. monocytogenes*, underscores a significant public health risk. High MAR indices observed in all isolates indicate substantial antibiotic exposure and classify them as high-risk sources. The findings highlight the urgent need for stringent monitoring, judicious antibiotic use, and improved food safety measures to prevent the spread of resistant *Listeria* strains.

Table 3: Distribution of MAR phenotypes and MAR index among *L. monocytogenes* isolates

Source	Sample ID	Multiple Antibiotic Resistance Phenotypes (MARPs)	MAR index
Bovine milk	CM114	AMP, C, CPM, GEN, CIP, LZ, TE, AMC, OX	0.64
	CM115	AMP, C, CPM, GEN, CIP, AMC, OX	0.50
	CM119	AMP, RIF, C, E, CPM, GEN, AMC, OX	0.57
	CM120	AMP, C, E, CPM, CD, AMC, OX	0.50
	BM123	AMP, C, CPM, GEN, LZ, TE, CD, AMC, OX	0.64
	BM150	AMP, C, E, CPM, GEN, CIP, AMC, OX	0.57
Milk products	CH214	AMP, C, CPM, GEN, CIP, LZ, TE, AMC, OX	0.64
	CH220	AMP, C, E, CPM, GEN, CIP, LZ, AMC, OX	0.64
	IC228	AMP, C, CPM, GEN, LZ, TE, AMC, OX	0.57
	CU283	AMP, RIF, C, E, CPM, GEN, CIP, LZ, TE, CD, MRP, AMC, OX	0.92
Animal clinical samples	F110	AMP, C, CPM, GEN, CIP, CD, AMC, OX	0.57
	F112	AMP, C, CPM, GEN, LZ, AMC, OX	0.50
	MM307	AMP, C, E, CPM, GEN, CIP, LZ, TE, AMC, OX	0.71

CM= Cow milk, BM=Buffalo milk, CH= Cheese, IC = Ice cream, CU = Curd, F= Faecal sample, MM= Mastitic milk

Table 4: Distribution of MAR phenotypes and MAR index among *Listeria* spp. other than *L. monocytogenes*

Source	Sample ID	Multiple Antibiotic Resistance Phenotypes (MARPs)	MAR index
Bovine milk	CM202	AMP, C, CM, GEN, LZ, TE, CD, AMC, OX	0.35
	BM206	AMP, C, CPM, GEN, LZ, TE, AMC, OX	0.57
	BM302	AMP, RIF,C, E, CPM, GEN, CIP, LZ, TE, CD, AMC, OX	0.57
	CM304	AMP, RIF, C, E, CPM, GEN, CIP, LZ, TE, CD, MRP, AMC,OX	0.71
Milk products	CU317	AMP, C, CPM, GEN, CIP, TE, AMC, OX	0.42

CM= Cow milk, BM=Buffalo milk, CH= Cheese, IC = Ice cream, CU = Curd, F= Faecal sample, MM= Mastitic milk

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References

Abdeen, E.E., Mousa, W.S., Harb, O.H., Fath-Elbab, G.A., Nooruzzaman, M., Gaber, A., & Abdeen, A. (2021). Prevalence, antibiogram and genetic characterization of *Listeria monocytogenes* from food products in Egypt. *Foods, 10*(6), 1381.

Aksoy, A., Sezer, C., Vatansever, L., & Gulbaz, G. (2018). Presence and antibiotic resistance of Listeria monocytogenes in raw milk and dairy products. *Kafkas Üniversitesi Veteriner Fakültesi Dergisi*, *24*(3), 415-421.

Barbuddhe, S.B., Kurkure, N.V., Dubal, Z.B., Doijad, P., & Poharkar, K.V. (2014). *Manual on Isolation of Listeria from Food and Clinical Samples*. Centre of Excellence and Innovation in Biotechnology, Nagpur Veterinary College, MAFSU, Nagpur, India, pp. 1-23.

Bauer, A.W, Kirby, W.M, Sherris, J.C, & Turck, M. (1966). Antibiotic susceptibility testing by a standardized single disk method. *American Journal of Clinical Pathology, 1*(45), 493-496.

Biswas, P., Deka, D., Dutta, T.K., Motina, E., & Roychoudhury, P. (2018). Conventional and molecular detection of *Listeria monocytogenes* and its antibiotic sensitivity profile from cattle sources of Aizawl, Mizoram (India). *International Journal of Current Microbiology and Applied Sciences*, *7*(11), 2829-2843.

Borena, B.M., Dilgasa, L., Gebremedhin, E.Z., Sarba, E.J., Marami, L.M., Kelbesa, K.A., & Tadese, N.D. (2022). *Listeria* species occurrence and associated risk factors and antibiogram of *Listeria monocytogenes* in milk and milk products in Ambo, Holeta, and Bako towns, Oromia Regional State, Ethiopia. *Veterinary Medicine International*, *2022*(1), 5643478.

Byun, K.H., Han, S.H., Choi, M.W., Kim, B.H., Park, S.H., & Ha, S.D. (2022). Biofilm eradication ability of phage cocktail against *Listeria monocytogenes* biofilms formed on food contact materials and effect on virulence-related genes and biofilm structure. *Food Research International*. *157*, 111367.

Choi, M.H., Park, Y.J., Kim, M., Seo, Y.H., Kim, Y.A., & Choi, J.Y. (2018). Increasing incidence of listeriosis and infection-associated clinical outcomes. *Annals of Laboratory Medicine*, *38*(2), 102-109.

Elavarasi, S., Ramesh, B., & Sathiyamurthy, K. (2023). Prevalence and antimicrobial resistance pattern of *Listeria monocytogenes* in ready to eat foods in Tamil Nadu, India. *Indian Journal of Science and Technology*, *16*(7), 501-508.

Esposito, C., Cardillo, L., Borriello, G., Ascione, G., Valvini, O., Galiero, G., & Fusco, G. (2021). First detection of *Listeria monocytogenes* in a buffalo aborted foetus in Campania Region (Southern Italy). *Frontiers in Veterinary Science*, *7*, 571-654.

Hassen, A., Keba, A., Ebrai, M.S., Mamo, H., Geleta, T.K., Tessema, T.S., & Zewdu, A. (2025). Prevalence of *Listeria monocytogenes* and *Listeria* species and associated risk factors for contamination of milk and cottage cheese along the value chains in Ethiopia. *International Journal of Food Microbiology*, *429*, 111021.

Iwu, C.D., & Okoh, A.I. (2020). Characterization of antibiogram fingerprints in *Listeria monocytogenes* recovered from irrigation water and agricultural soil samples. *PLoS One*, *15*(2), e0228956.

Jamali, H., Paydar, M., Ismail, S., Looi, C.Y., Wong, W.F., Radmehr, B., & Abedini, A. (2015). Prevalence, antimicrobial susceptibility and virulotyping of *Listeria* species and *Listeria monocytogenes* isolated from open-air fish markets. *BMC Microbiology*, *15*(1), 144.

Kayode, A.J., & Okoh, A.I. (2022). Assessment of multidrug-resistant *Listeria monocytogenes* in milk and milk product and One Health perspective. *PLoS One*, *17*(7), e0270993.

Krumperman, P.H. (1983). Multiple antibiotic resistances indexing of *Escherichia coli* to identify high-risk sources of fecal contamination of foods. *Applied and Environmental Microbiology*, *46*(1), 165-170.

Malakar, D., Borah, P., Das, L., Mathipi, V., Sailo, C.V., Dutta, R., & Kumar, N.S. (2020). Prevalence and virulent gene profiling of *Listeria monocytogenes* from fish and meat samples from Aizawl, Mizoram. *Journal of Pure and Applied Microbiology*, *14*(2), 1359-1365.

Marian, M.N., Aminah, S.S., Zuraini, M.I., Son, R., Maimunah, M., Lee, H.Y., & Elexson, N. (2012). MPN-PCR detection and antimicrobial resistance of *Listeria monocytogenes* isolated from raw and ready-to-eat foods in Malaysia. *Food Control*, *28*(2), 309-314.

Matyar, F.A.T.İ.H., Guzeldag, G., & Mercimek, H.A. (2010). Multiple antibiotic resistance among *Listeria monocytogenes* in retail foods, in Adana, Turkey. *Italian Journal of Food Science*, *22*(4), 467.

Maurella, C., Gallina, S., Ru, G., Adriano, D., Bellio, A., Bianchi, D.M., & Decastelli, L. (2018). Outbreak of febrile gastroenteritis caused by *Listeria monocytogenes* 1/2a in sliced cold beef ham, Italy, May 2016. *Euro Surveillance*, *23*(10), 17-155.

Maurice, B.L., Sin Chai, L., Tahar, A.S., Ted, C.K., & Apun, K. (2018). Prevalence, genetic heterogeneity, and antibiotic resistance profile of *Listeria* spp. and *Listeria monocytogenes* at farm level: A highlight of ERIC-and BOX-PCR to reveal genetic diversity. *BioMed Research International*, *2018*(1), 3067494.

Mohamed, H.M.A., Katreen, K.G., Abd Al-Azeem, M.W., Wasel, F.A., & Abd-Eldayem, A.M. (2022). Molecular detection of *Listeria* species isolated from raw milk with special reference to virulence determinants and antimicrobial resistance in *Listeria monocytogenes*. *Journal of Animal Health and Production, 10*(4), 492-505.

Mpundu, P., Mbewe, A.R., Muma, J.B., Mwasinga, W., Mukumbuta, N., & Munyeme, M. (2021). A global perspective of antibiotic-resistant *Listeria monocytogenes* prevalence in assorted ready to eat foods: A systematic review. *Veterinary World*, *14*(8), 2219.

Sambyal, N., Rashid, M., Kotwal, S.K., & Rehman, M.U. (2017). Multidrug resistant *Listeria* species from milk and milk products. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*, *87*(4), 1423-1427.

Sarangi, L.N., Panda, H.K., Priyadarshini, A., Sahoo, S., Palai, T.K., Ranabijuli, S., & Mohanty, D. N. (2009). Prevalence of *Listeria* species in milk sample of cattle of Odisha. *Indian Journal of Comparative Microbiology, Immunology and Infectious Diseases, 30*(2), 135-136.

Shourav, A.H., Hasan, M., & Ahmed, S. (2020). Antibiotic susceptibility pattern of Listeria spp. isolated from cattle farm environment in Bangladesh. *Journal of Agriculture and Food Research*, *2*, 100082.

Sonar, S.S. (2010). Isolation, identification and characterization of *Listeria* species from market milk. *Master's Thesis*, Anand Agricultural University, Anand, Gujarat, India.

Suryawanshi, R., Bhosale, A., Bharkad, G., Shinde, O., Jogdand, A., Hatwar, N., & Kamat, H. (2023). Application of MALDI-TOF Mass Spectrometry for the assessment of prevalence of *Listeria monocytogenes* in raw milk, dairy products and freshwater fishes. *Asian Journal of Dairy and Food Research*, *42*(3), 415-419.

Swetha, C.S., Porteen, K., Elango, A., Ronald, B.S.M., Kumar, T.S., Milton, A.P., & Sureshkannan, S. (2021). Genetic diversity, virulence and distribution of antimicrobial resistance among Listeria monocytogenes isolated from milk, beef, and bovine farm environment. *Iranian Journal of Veterinary Research*, *22*(1), 1.

Tahoun, A.B., Abou Elez, R.M., Abdelfatah, E.N., Elsohaby, I., El-Gedawy, A.A., & Elmoslemany, A.M. (2017). *Listeria monocytogenes* in raw milk, milking equipment and dairy workers: Molecular characterization and antimicrobial resistance patterns. *Journal of Global Antimicrobial Resistance*, *10*, 264-270.

Usman, U.B., Kwaga, J.K.P., Kabir, J., & Olonitola, O.S. (2016). Isolation and antimicrobial susceptability of *Listeria monocytogenes* from raw milk and milk products in Northern Kaduna State, Nigeria. *Journal of Applied & Environmental Microbiology*, *4*(3), 46-54.

Wang, Z., Tao, X., Liu, S., Zhao, Y., & Yang, X. (2021). An update review on *Listeria* infection in pregnancy. *Infection and Drug Resistance*, *14*, 1967-1978.

Warke, S., Ingle, V., & Tumlam, U. (2019). Isolation and molecular characterization of *Listeria monocytogenes* in bovine and their environment. *Journal of Entomology and Zoology Studies, 7*(6), 339-348.

Warke, S.R. (2022). Molecular Characterization of *L. monocytogenes* Isolated from milk and milk products. *The Indian Journal of Veterinary Sciences & Biotechnology, 18*(3), 108-111.

Wong, W.C., Pui, C.F., Tunung, R., Cheah, Y.K., Nakaguchi, Y., Nishibuchi, M., & Son, R. (2012). Prevalence of *Listeria monocytogenes* in frozen burger patties in Malaysia. *International Food Research Journal, 19*(4), 1756.

Wu, L., Bao, H., Yang, Z., He, T., Tian, Y., Zhou, Y., & Zhang, H. (2021). Antimicrobial susceptibility, multilocus sequence typing, and virulence of isolates from a slaughterhouse in Jiangsu, China. *BMC Microbiology, 21*(1), 327.

Zeinali, T., Jamshidi, A., Bassami, M., & Rad, M. (2017). Isolation and identification of Listeria spp. in chicken carcasses marketed in northeast of Iran. *International Food Research Journal, 24*(2), 881-887.