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Research Article

Prevalence of *Listeria monocytogenes* in dairy products in Turkey: A meta-analysis

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ABSTRACT

This study was aimed to conduct a meta-analysis to determine the prevalence of Listeria monocytogenes in dairy products in Turkey. A systematic literature search was conducted using the Medline/PubMed, Science Direct, Web of Science, and Scopus databases to identify studies reporting the prevalence of L. monocytogenes in dairy products. The search was conducted using the following keywords: ("ice cream" or "curd" or "cream" or "cheese" or "butter" or "yoghurt" or "dairy" or "milk") and ("Listeriosis" or "Listeria monocytogenes" or "Listeria") and ("Turkiye" or "Turkey") and ("seropositivity" or "seroprevalence" or "prevalence"). A comprehensive meta-analysis included a total of 4615 dairy products from the 26 studies. The overall molecular prevalence of L. monocytogenes in dairy products in Turkey was estimated to be 4.3% (95% confidence interval [CI]: 3.7-4.9%). The I2 value of 87.4% (CI95%82.8–90.8) suggested high heterogeneity, with a τ2 of -0.6227 (CI95%-4.6556–3.4102), and an X2 statistic of 199.0 ($P < 0.0001$). In conclusion, this meta-analysis reveals a significant prevalence of L. monocytogenes in dairy products in Turkey. The findings highlight the need for improved control measures to minimize the risk of contamination and ensure consumer safety. By implementing rigorous hygiene practices, enhancing monitoring systems, and promoting collaborative efforts between industry and regulatory bodies, the dairy sector in Turkey can effectively mitigate the risks associated with L. monocytogenes and maintain high standards of food safety.

INTRODUCTION

Listeriosis is a severe and significant food-borne disease caused by the bacterium *Listeria monocytogenes* (Ulusoy and Chirkena, 2019). This organism can contaminate food at various stages of production before it is consumed. Upon ingestion, the pathogen traverses the intestinal barrier and disseminates through the bloodstream and lymphatic system, ultimately reaching the liver and spleen, where it can proliferate (Andersson et al., 2015). *L. monocytogenes* is an opportunistic human pathogen that can cause meningitis or septicaemia, with a higher risk for pregnant women, the eldexxxxxxrly, and individuals with compromised immune systems. Immunocompromised individuals are particularly susceptible to this intracellular pathogen (Ramaswarmy et al., 2007). In pregnant women, *L. monocytogenes* can lead to severe infection in the fetus through vertical transmission via the placenta (Cossart, 2011). According to the World Health Organization report (2018), pregnant women are approximately 20 times more likely to contract *Listeriosis* compared to healthy adults, as the disease can result in miscarriage or stillbirth. Furthermore, individuals with HIV/AIDS are at least 300 times more susceptible to the infection compared to those with a normal immune system.

In Turkey, the dairy industry stands out as a highly dynamic sector within the farming industry (Akin et al., 2022). Turkey is recognized as the 10th largest milk producer globally, according to Yonar et al. (2022). As of 2021, Turkey's annual milk production amounts to approximately 23.2 million tonnes, with milking cows contributing nearly 21.4 million tonnes (Tuik, 2022). The collected milk undergoes processing to produce various dairy products, including drinking milk, cheese, yogurt, ayran, butter, kefir, milk cream, and ice cream (Bor, 2014). *L. monocytogenes* can contaminate a wide range of food products, including dairy items. As in other countries, Turkey also faces the potential risk of *L. monocytogenes* contamination in its dairy products (Cetinkaya and Soyutemiz, 2007; Kevenk and Gulel, 2016).

Meta-analysis is a statistical technique widely employed in the field of food science and nutrition to amalgamate and analyze data from multiple independent studies (Bouras et al., 2019). One primary advantage is that meta-analysis allows researchers to obtain a more precise estimate of the effect of a specific food or dietary pattern on health outcomes (Kelley and Kelley, 2019). By pooling data from multiple studies, meta-analysis enhances the statistical power of the analysis and mitigates the impact of random variation in individual studies, thereby yielding a more accurate estimation of the true effect size (Lee, 2019). Furthermore, meta-analysis facilitates the identification of sources of heterogeneity or inconsistency among studies, enabling exploration of potential biases or confounding factors. Consequently, meta-analysis provides a robust and comprehensive evaluation of the evidence base in food-related studies, informing future research directions and shaping public health policies (Nardi et al., 2020).

To the best of author knowledge, no previous meta-analysis

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has specifically focused on the prevalence of *L. monocytogenes* in dairy products in Turkey. Therefore, the aim of this study was to conduct a meta-analysis to determine the prevalence of *L. monocytogenes* in dairy products in Turkey and provide insights into the potential public health risks associated with the consumption of contaminated dairy products. Furthermore, the study has the potential to guide the implementation of effective preventive measures, ultimately reducing the risk of *L. monocytogenes* transmission to humans.

MATERIALS and METHODS

Literature search and study selection

The systematic review and meta-analysis adhered to the guidelines set forth by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher et al., 2009). A thorough literature search was conducted across multiple databases, including Medline/PubMed, Science Direct, Web of Science, and Scopus, to identify relevant studies reporting on the prevalence of *L. monocytogenes* in dairy samples. The search was conducted using the following keywords: ("ice cream" or "curd" or "cream" or "cheese" or "butter" or "yoğurt" or "dairy" or "milk") and ("Listeriosis" or "Listeria monocytogenes" or "Listeria") and ("Turkiye" or "Turkey") and ("seropositivity" or "seroprevalence" or "prevalence"). The search was confined to studies published in the English language within the timeframe of January 2000 to July 2023.

Inclusion criteria

In order to identify any additional pertinent studies, a manual search of the reference lists of the identified studies was conducted. The full texts of potentially eligible studies were carefully reviewed to assess their compliance with the inclusion criteria. To be considered eligible for inclusion, studies had to meet the following criteria: (1) report on the prevalence of *L. monocytogenes* in dairy samples, (2) provide adequate data for calculating the prevalence estimate and its confidence interval, and (3) be original studies rather than review articles.

Data extraction and meta-analysis

A standardized form was used to extract data from eligible studies. This form included the following information: author, year of publication, study area, period of study, kind of dairy product, number of dairy products tested, number of positive samples, prevalence, and confidence interval.

The meta-analysis conducted in this study utilized the prevalence of *L. monocytogenes* detected in dairy products as the dependent variable, serving as the effect size for the analysis. The methodology employed in this meta-analysis followed the previous approach outlined by Wang (2018). Initially, the heterogeneity among the included studies was assessed using Cochran's Q (X^2) test, which examines the null hypothesis of homogeneity. Additionally, the degree of heterogeneity was quantified using the Higgins' I^2 statistic proposed by Borenstein et al. (2021). Considering the observed high level of heterogeneity, a random-effects model was employed to estimate the overall weighted prevalence of *L. monocytogenes*. This model accounted for both within-study variance (sampling error) and between-studies variance (τ^2). The results of the meta-analysis, including the corresponding 95% confidence interval (CI)s, were presented using forest plots. To investigate the possibility of publication bias for studies with low or high effect sizes, Egger's test was utilized (Egger et al., 1997). All statistical analysis were performed using commercial software (Med-Calc; version 20.110; MedCalc Software Ltd).

RESULTS

After conducting an initial search, a total of 210 articles were identified. Among them, 26 articles were deemed suitable based on the inclusion criteria. The study selection process is outlined in Figure 1, while the characteristics of the selected

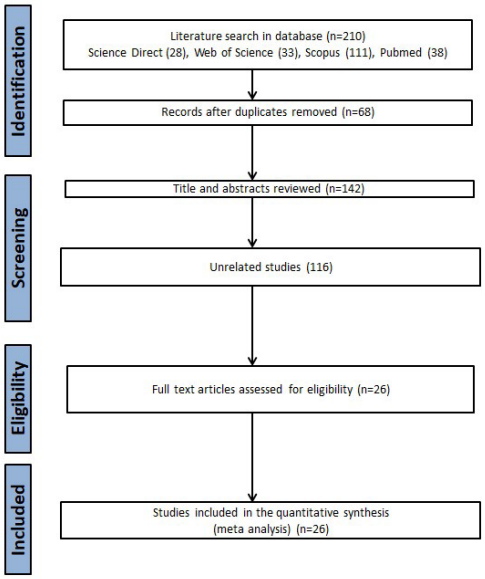

Figure 1. PRISMA flow diagram depicting the study selection process for the meta-analysis investigating the prevalence and source analysis of Listeria monocytogenes in dairy products.

studies can be found in Table 1. These studies were carried out in six distinct geographical regions of Turkey: the Marmara region (7 studies), Black Sea region (5 studies), Central Anatolian region (4 studies), Mediterranean region (3 studies), Eastern Anatolian region (1 study), and Southeastern Anatolian region (4 studies). Moreover, the geographical categorization of one study remained unspecified, while one study encompassed more than two distinct geographical regions. These studies were published between 2001 and 2020. A comprehensive meta-analysis included a total of 4615 dairy products from the 26 studies (Table 1).

The median size of eligible studies was 6, and out of the total 4615 samples, 231 were diagnosed as positive by serologic methods. The overall molecular prevalence of *L. monocytogenes* in dairy products in Turkey was estimated to be 4.3% (CI_{95}%: 3.7-4.9%). The I^2 value of 87.4% (CI_{95}%82.8–90.8) suggested high heterogeneity, with a τ^2 of -0.6227 (CI_{95}%-4.6556–3.4102), and an X^2 statistic of 199.0 ($P < 0.0001$). The overall meta-analysis is shown in a forest plot (Figure 2). The meta-analysis showed no significant evidence of publication bias based on Egger's test ($P = 0.7527$).

Table 1. Characteristics and main results of the eligible studies ordered by Prevalence of Listeria monocytogenes in dairy products in Turkey.

Author and Year	Geographical region	Period of study	Dairy product	Ns	Ps	Proportion (95% CI)
Kahraman et al. 2010	Marmara	2007-2008	Cheese	280	7	2.5 (1.0-5.1)
Kevenk and Gulel, 2016	Black Sea	2011-2012	Butter, cheese, cokelek, ice cream, kuymak	210	14	6.7 (3.7-10.9)
Kevenk and Koluman, 2022	Central Anatolian	2020-2021	Cheese	400	44	11.0 (8.1-14.5)
Karadal and Yildirim, 2014	Central Anatolian	2011	Cheese	200	2	1.0 (0.1-3.6)
Matyar et al. 2010	Mediterranean	2008	Cheese, ice cream, milk	101	8	7.9 (3.5-15.0)
Oktem et al. 2006	Central Anatolian	2001-2002	Cheese	100	4	4.0 (1.1-9.9)
Sagun et al. 2001	Eastern Anatolian	ND	Cheese, milk	504	13	2.6 (1.4-4.4)
Turhan, 2019	Mediterranean	ND	Cheese	20	0	0.0 (0.0-16.8)
Tasci et al. 2010	Mediterranean	2007-2008	Milk	175	1	0.6 (0.0-3.1)
Yigin et al. 2020	Southeastern Anatolian	ND	Cheese	103	6	5.8 (2.2-12.2)
Sanlibaba et al. 2018	Central Anatolian	2017	Cheese, milk	110	5	4.5 (1.5-10.3)
Abay et al. 2012	ND	2008-2009	Milk	150	0	0.0 (0.0-2.4)
Aksoy et al. 2018	Southeastern Anatolian	2012-2013	Butter, cheese, milk	300	22	7.3 (4.6-10.9)
Arslan and Ozdemir, 2008	Black Sea	ND	Cheese	142	13	9.2 (5.0-15.1)
Aygun and Pehlivanlar, 2006	Southeastern Anatolian	ND	Butter, cheese, milk, yoghurt	157	2	1.3 (0.2-4.5)
Arslan and Ozdemir, 2020	Black Sea	2016	Cheese, ice cream	67	0	0.0 (0.0-5.4)
Aydin et al. 2019	Marmara	ND	Milk	150	4	2.7 (0.7-6.7)
Cagri-Mehmetoglu et al. 2011	Marmara	2008-2010	Cheese, milk	24	0	0.0 (0.0-14.2)
Babacan, 2020	Black Sea	2013-2017	Cream cake, ice cream	128	16	12.5 (7.3-19.5)
Cetinkaya et al. 2014	Marmara	2009-2010	Butter, cheese, ice cream, milk, yoghurt	196	0	0.0 (0.0-1.9)
Cokal et al. 2012	Marmara	2010-2011	Cheese, dessert	200	8	4.0 (1.7-7.7)
Durmaz et al. 2015	Southeastern Anatolian	ND	Milk	140	3	2.1 (0.4-6.1)
Guner and Telli, 2011	Mediterranean, Eastern and Central Anatolian	ND	Cheese	120	34	28.3 (20.5-37.3)
Ekici et al. 2019	Marmara	ND	Cheese, cream	200	6	3.0 (1.1-6.4)
Gulel et al. 2020	Black Sea	2012-2013	Cheese, cream, milk	188	7	3.7 (1.5-7.5)
Colak et al. 2007	Marmara	2004-2005	Cheese	250	12	4.8 (2.5-8.2)
Total				4615	231	4.3 (3.7-4.9)

ND: Not determined, Ns: Number of samples, Ps: Positive samples

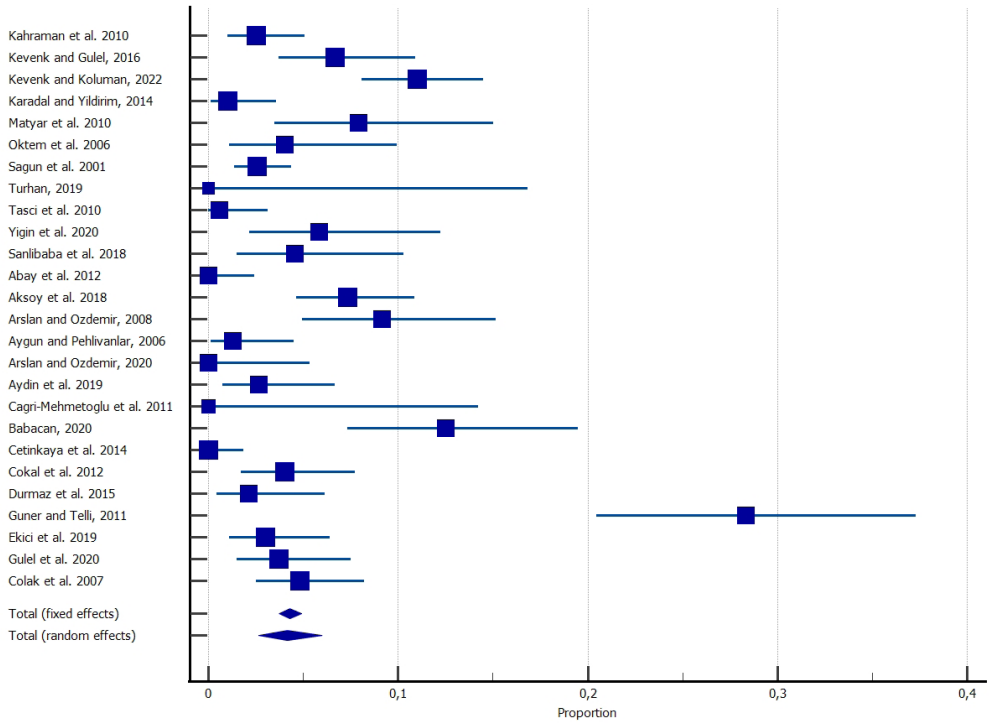

Figure 2. Forest plot illustrating the results of the meta-analysis evaluating the prevalence of Listeria monocytogenes in dairy products. The plot includes data from twenty-seven studies that met the inclusion criteria outlined in the meta-analysis.

DISCUSSION

The present study aimed to investigate the prevalence of *L. monocytogenes* in dairy products in Turkey through a comprehensive meta-analysis. The findings provide valuable insights into the prevalence and potential risks associated with *L. monocytogenes* contamination in the dairy industry, highlighting the need for effective control measures. The meta-analysis revealed an overall prevalence rate of 4.3% (CI_{95}% 3.7-4.9) across the included studies. This indicates a significant presence of *L. monocytogenes* in dairy products in Turkey. The high prevalence rate emphasizes the importance of implementing stringent quality control measures throughout the dairy production chain to minimize the risk of contamination.

Several factors contribute to the observed prevalence rates of *L. monocytogenes* in dairy products. One crucial factor is the contamination of raw milk, which serves as the primary source of *L. monocytogenes* ocytogenes in dairy production. Studies have shown that *L. monocytogenes* can colonize the udder and persist in raw milk, leading to subsequent contamination of dairy products during processing and packaging (Jiang et al., 2022). Inadequate hygiene practices during various stages of dairy production can also facilitate *L. monocytogenes* transmission. Contaminated equipment, unclean surfaces, and improper temperature control are all potential factors contributing to the survival and growth of *L. monocytogenes* in the production environment (Mazaheri et al., 2021).

The diversity of dairy products included in this meta-analysis is worth noting, as it reflects the wide range of products consumed in Turkey. The analysis encompassed milk, cheese, yogurt, and butter, among others. Interestingly, our findings indicate that certain types of dairy products especially cheese had high prevalence rate. This finding is consistent with previous studies that have identified cheese as a potential source of *L. monocytogenes* contamination due to its favorable pH and moisture conditions for bacterial growth (Falardeau et al., 2021).

Despite the valuable insights gained from this meta-analysis, several limitations should be acknowledged. The included studies varied in sample size, geographic location, and detection methods, which may introduce heterogeneity into the analysis. Publication bias is another potential limitation, as studies reporting higher prevalence rates may be more likely to be published. Future research should focus on standardizing sampling methods, laboratory techniques, and reporting criteria to enhance the comparability of data.

To mitigate the risks associated with *L. monocytogenes* in dairy products, a multifaceted approach involving industry and regulatory bodies is necessary. Dairy producers should prioritize regular monitoring of their production facilities, implement strict hygiene practices, and invest in advanced technologies for rapid detection and elimination of the pathogen (Ntuli et al., 2023). Additionally, regulatory authorities should enforce stringent food safety regulations, conduct regular inspections, and provide educational programs to raise awareness among dairy industry professionals about the importance of *L. monocytogenes* control (Ricci et al., 2018).

CONCLUSION

In conclusion, this meta-analysis reveals a significant prevalence of *L. monocytogenes* in dairy products in Turkey. The findings highlight the need for improved control measures to minimize the risk of contamination and ensure consumer safety. By implementing rigorous hygiene practices, enhancing monitoring systems, and promoting collaborative efforts between industry and regulatory bodies, the dairy sector in Turkey can effectively mitigate the risks associated with *L. monocytogenes* and maintain high standards of food safety.

DECLARATIONS

Ethics Approval

Not applicable.

Conflict of Interest

The authors declare no coflict of interest

Author contribution

Idea, concept and design: BY

Data collection and analysis: BY

Drafting of the manuscript: BY

Critical review: BY

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