PREVALENCE AND DISTRIBUTION OF MICROBIAL CONTAMINATION IN RAW MILK AND PROCESSED DAIRY PRODUCTS IN JOS METROPOLIS

ABSTRACT

The study investigates the microbial contamination of dairy products collected from four locations within Jos Metropolis;Tina Junction, FarinGada, Terminus, and Katako. A total of 200 dairy samples, including raw milk, *Nono*(fermented milk), Cheese, and Yoghurt, were aseptically collected and analyzed using standard microbiological methods. The results revealed significant variations in bacterial prevalence across locations and product types. *Bacillus* spp. was the most frequently isolated bacterium; it was detected in 144 samples (72.0%), with the highest prevalence in raw milk (94.0%) and *nono* (92.0%). *Mycobacterium bovis* (*M. bovis*) was detected exclusively in raw milk (6.0%), indicating a potential risk of zoonotic transmission through unpasteurized dairy. Processed dairy products had a higher occurrence of yeast cells (13.2%), *Micrococcus* (2.8%), and *Staphylococcus* (10.4%), suggesting contamination may have occurred during processing and or storage. Among sampling locations, FarinGada and Katako had the highest microbial prevalence of 92.0% and 82.0%, respectively, while Tina Junction and Terminus recorded lower contamination levels (60.0% each). Raw milk had prevalence of 34.7% compared to processed dairy products (94.0%), it was concluded that , raw milk poses a significant risk of microbial contamination, while processed dairy products are susceptible to post-processing contamination. Given the high prevalence of *Bacillus spp.* (72.0%) and the presence of *M. bovis* in raw milk, all raw dairy products should undergo pasteurization or other heat treatments before consumption to eliminate harmful pathogens are recommended.

INTRODUCTION

The presence of pathogenic bacteria such as *Listeria monocytogenes*, *Escherichia coli*, *Salmonella* spp., and *Staphylococcus aureus* in raw and processed dairy products is a global public health concern, especially in developing regions with weak regulatory enforcement (Koski*et al*., 2022). Raw milk's high nutrient content and neutral pH make it an ideal medium for microbial growth, and contamination can occur at any stage production, handling, storage, or transportation (Velázquez-Ordoñez*et al*., 2019; Peng*et al*., 2023).Sources of contamination include poor farm hygiene, mastitis in animals, contaminated water, and improper handling practices (Adamski*et al*., 2023). Additionally, failures in cold chain logistics can facilitate microbial proliferation (Praça*et al*., 2023). Peng*et al*. (2023) reported that 9.89% of raw milk samples exceeded safe aerobic plate counts, with over 54% containing aerobic *Bacillus* spp. and 36.18% exhibiting high alkaline phosphatase activity indicators of poor hygiene.Even post-processing techniques like pasteurization may not eliminate all pathogens. Spores from *Bacillus*and *Clostridium* spp. can survive heat treatment and contaminate products during packaging and distribution (Mariam, 2021). Koski*et al*. (2022) found a link between unpasteurized milk availability and foodborne outbreaks in the U.S., while Praça*et al*. (2023) detected *L. monocytogenes* and *E. coli* in raw milk cheese samples in Portugal.These pathogens

pose serious health risks *E. coli* (especially STEC) can cause hemorrhagic colitis, *Listeria* can lead to miscarriage or death in vulnerable individuals, *Salmonella* causes gastroenteritis, and *S. aureus* produces heat-resistant enterotoxins (Adamski*et al*., 2023; Praça*et al*., 2023). The emergence of antimicrobial resistance further complicates the issue.Addressing contamination requires good agricultural practices (GAPs), including farm hygiene, animal health monitoring, and proper milking procedures. Processing plants must enforce pasteurization, prevent post-processing contamination, and maintain the cold chain. Advanced diagnostics such as PCR and genome sequencing are crucial for early detection (Martin *et al*., 2023).

MATERIALS AND METHODS

3.1 Study Area

The study was conducted in Jos, the capital of Plateau State in North Central Nigeria. Plateau State spans approximately 26,899 km² and is home to about three million people (National Population Commission, 2006). Located between latitudes 08°24'N and longitudes 008°32'–010°38'E, the state is named after the Jos Plateau a high-altitude region marked by unique rock formations, extensive grasslands, and elevations ranging from 1,200 m to 1,829 m at Shere Hills.The area's history of tin and columbite mining has shaped its landscape, leaving behind gorges and artificial lakes. Due to its elevation, Plateau State experiences a near-temperate climate, with average temperatures between 13°C and 22°C. The coldest months occur between December and February, while March and April are the hottest. Annual rainfall averages 131.75–146 cm, peaking in July and August.Jos' cooler climate contributes to lower incidences of certain tropical diseases, such as malaria. The Plateau also functions as a major watershed, giving rise to key rivers in northern Nigeria, including the Kaduna, Gongola, Hadejia, and Yobe Rivers.

3.2 Sample Collection and Distribution

A total of 200 dairy product samples were collected from four major locations within Jos Metropolis Tina Junction, FarinGada, Terminus, and Katakowith each location contributing 50 samples to ensure even distribution. The dairy products sampled included raw milk, *nono*(a traditional fermented milk), cheese, and yoghurt, with 50 samples collected for each product type.The sample size was determined based on resource availability, feasibility, and the need for statistical reliability in assessing the microbiological quality and diversity of dairy products sold in the area. Samples were aseptically collected into sterile containers, appropriately labeled, and immediately transported in ice-cooled boxes to the laboratory for microbiological analysis.

3.3 Bacteriological Analysis

For microbiological evaluation, 50 mL of raw milk and 10 grams of each processed dairy product (nono, cheese, and yoghurt) were aseptically collected into sterile containers. The samples were immediately transported under chilled conditions (maintained at 4°C) to the National Veterinary Research Institute (NVRI) laboratory in Jos for bacteriological analysis. All

procedures followed standard microbiological protocols to ensure the accuracy and reliability of results.

3.3.1 Isolation of *Bacillus* spp.

Samples were cultured on Nutrient Agar (NA) and incubated at 37°C for 24 to 48 hours to isolate *Bacillus* species. Colonies displaying typical *Bacillus* morphology such as large, rough, irregular edges and opaque appearance were further subjected to Gram staining. Biochemical confirmation was performed using catalase and oxidase tests to distinguish *Bacillus* from other Gram-positive spore-formers.

3.3.2 Detection of *Mycobacterium bovis*

Detection of *Mycobacterium bovis* was conducted using Ziehl-Neelsen staining to identify acid-fast bacilli. Samples that tested positive for acid-fast organisms were further confirmed through polymerase chain reaction (PCR)-based identification to ensure specificity and accuracy of *M. bovis* detection.

3.3.3 Isolation of Yeast, *Micrococcus*, and *Staphylococcus* spp.

Yeast cells were isolated using Sabouraud Dextrose Agar (SDA) and incubated at 25°C for 48 to 72 hours. Colonies with yeast-like morphology were subjected to microscopic examination for confirmation.

Micrococcus and *Staphylococcus* species were isolated using Mannitol Salt Agar (MSA), which supports the selective growth of salt-tolerant organisms. Presumptive colonies were further characterized using a series of biochemical tests, including coagulase, catalase, and sugar fermentation assays, to differentiate and identify specific bacterial species.

3.4 Data Analysis

The prevalence of bacterial contamination was determined as percentages and presented in tables. The data were statistically analyzed using descriptive statistics (percentages and frequency distributions) to compare bacterial contamination across sampling locations and dairy product types.

5.1 Prevalence and Distribution of Microbial Contamination by Location

The study revealed notable variations in microbial contamination across sampling sites, largely influenced by handling, processing, and storage practices. *Bacillus* species were the most frequently isolated organisms, with an overall prevalence of 72.0%, particularly high in FarinGada (88.0%) and Katako (80.0%). This aligns with Edema and Akingbade (2007), who reported a high presence of spore-forming bacteria in dairy products, often linked to poor

hygiene and environmental exposure.*Mycobacterium bovis* was detected in only 1.5% of samples, found exclusively in FarinGada (4.0%) and Katako (2.0%), indicating sporadic occurrence likely tied to localized handling conditions. The absence of *Yeast*, *Micrococcus*, and *Staphylococcus* spp. suggests relatively good sanitary practices in preventing contamination by these organisms.These results are consistent with Attah*et al*. (2021) and Anagboso*et al*. (2024), who emphasized that poor sanitation, improper storage, and inadequate post-milking hygiene significantly contribute to microbial contamination. The findings reinforce the need for improved hygiene protocols, better handling practices, and continuous microbial monitoring in milk production and distribution systems.

Table 1: Prevalence of Microbial Contamination and Distribution by Sampling Location

Sampling Location	Total Samples Collected	Bacillus	*M. bovis*	Yeast Cell	*Micrococcus*	*Staphylococcus*	Overall Prevalence (%)
Tina Junction	50	30(60.0)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	60.0
FarinGada	50	44(80.0)	2(4.0)	0(0.00)	0(0.00)	0(0.00)	92.0
Terminus	50	30(60.0)	0.00)	0(0.00)	0(0.00)	0(0.00)	60.0
Katako	50	40(80.0)	1(2.00)	0(0.00)	0(0.00)	0(0.00)	82.0
Total	**200**	**144 (72.0)**	**3(1.50)**	**0(0.00)**	**0(0.00)**	**0(0.00)**	**73.5**

5.2 Prevalence and Distribution of Microbial Contamination in Raw Milk and Its Products

The study findings are consistent with existing literature on microbial contamination in dairy products. *Bacillus* spp. showed the highest prevalence in raw milk (94.0%), confirming their widespread occurrence and resistance to pasteurization, as reported by Tan *et al*. (2020). The exclusive detection of *Mycobacterium bovis* in raw milk (6.0%) reinforces concerns about consuming unpasteurized milk and supports prior findings on its health risks (Eltokhy*et al*., 2021).Yeast cells were found in fermented products nono (8.0%), cheese (12.0%), and yoghurt (18.0%) indicating the influence of fermentation on yeast growth. While generally sensitive to thermal and pressure treatments, some heat-resistant molds can survive, posing spoilage and safety risks (Pal *et al*., 2016).The presence of *Staphylococcus* spp. in yoghurt (30.0%) suggests possible post-processing contamination, likely due to inadequate hygiene during handling and storage. This aligns with Agarwal*et al*. (2012), who reported similar contamination patterns in dairy products linked to poor sanitary conditions. These findings emphasize the importance of strict hygiene and pasteurization to ensure dairy safety.

Table 2: Prevalence of Microbial Contamination and Distribution in Raw Milk and its Products

Sample Type	Total Samples Collected	*Bacillus* (%)	*M. bovis* (%)	Yeast Cell (%)	*Micrococcus* (%)	*Staphylococcus* (%)
Raw Milk	50	47 (94.00)	3 (6.00)	0 (0.00)	0 (0.00)	0 (0.00)
Nono	50	46 (92.00)	0 (0.00)	4 (8.00)	0 (0.00)	0 (0.00)
Cheese	50	29 (58.00)	0 (0.00)	6 (12.00)	4 (8.00)	0 (0.00)
Yoghurt	50	22 (44.00)	0 (0.00)	9 (18.00)	0 (0.00)	15 (30.00)
Total	**200**	**144 (72.00)**	**3 (1.50)**	**19(9.50)**	**4(2.00)**	**15(7.50)**

5.3 Comparison of Microbial Contamination in Raw and Processed Dairy Products

The study revealed a higher prevalence of *Bacillus* isolates in processed dairy products (67.4%) compared to raw milk (32.6%), suggesting that while pasteurization reduces many pathogens, it does not eliminate heat-resistant *Bacillus* spp. This supports findings by Ledenbach and Marshall (2009) and Pal *et al*. (2016), who noted the ability of *Bacillus* spores to survive pasteurization and germinate under favorable storage or handling conditions.*Mycobacterium bovis* was exclusively detected in raw milk (2.1%), underscoring the health risks of consuming unpasteurized milk. Its absence in processed dairy highlights the effectiveness of pasteurization in eliminating zoonotic pathogens (Li, 2022; Kahla*et al*., 2011).The detection of yeast (13.2%) and *Micrococcus* (2.8%) mainly in processed products suggests contamination during fermentation or post-processing stages. Yobouet*et al*. (2014) reported similar findings, emphasizing the vulnerability of dairy products to contamination during handling and packaging.The presence of *Staphylococcus* spp. (10.4%) particularly in yoghurt points to post-pasteurization contamination, likely linked to inadequate sanitation. Previous studies by Svenssone*t al*. (2000) and Collins *et al*. (2022) have shown that poor hygiene and contaminated equipment in dairy plants can facilitate the persistence and spread of such bacteria in processed products.These findings reinforce the need for comprehensive hygiene controls throughout dairy processing to prevent contamination, especially by heat-resistant and post-processing-introduced microbes.

Table 3 Comparison of Microbial Contamination and Distribution in Raw and Processed Dairy Products

Dairy Category	*Bacillus*	*M. bovis*	Yeast Cell	*Micrococcus*	*Staphylococcus*	Overall Prevalence (%)
Raw Milk	47(32.6)	3(2.10)	0(0.00)	0(0.00)	0(0.00)	34.7

Processed Dairy *Nono*, Cheese and Yoghurt	97(67.4)	0(0.00)	19(13.2)	4(2.80)	15(10.4)	94.0
Total	**144(72.0)**	**3(1.5)**	**19(9.50)**	**4(2.00)**	**15(7.50)**	**73.5**

Conclusion and Recommendations

This study highlights significant microbial contamination in dairy products across Jos Metropolis, with *Bacillus* spp. showing the highest prevalence (72.0%) and *Mycobacterium bovis* detected exclusively in raw milk (6.0%). Contamination levels varied by location and product type, with raw milk posing the greatest health risk due to its high microbial load. Processed dairy products showed evidence of secondary contamination particularly with yeast, *Staphylococcus*, and *Micrococcus* spp. likely introduced during fermentation or post-processing.

To mitigate these risks, several actions are recommended:

Mandatory pasteurization or heat treatment of all raw dairy products before consumption is essential to eliminate harmful pathogens.

Strict hygiene protocols should be enforced among dairy farmers and vendors, including proper milking, equipment sanitation, and safe handling practices.

Cold chain maintenance (≤4°C) must be prioritized across the dairy supply chain, supported by investments in refrigeration and temperature-controlled transportation.

Routine microbiological surveillance at production, processing, and retail levels is crucial to monitor contamination trends and enforce food safety standards.

Public health education campaigns should raise awareness about the risks of consuming unpasteurized dairy products, while regulatory agencies ensure vendor compliance with hygiene laws.

Support for small-scale producersthrough training, technical assistance, and access to equipment subsidies will promote safer production practices and reduce contamination risks.

REFERENCES

Adamski, P., Byczkowska-Rostkowska, Z., Gajewska, J., Zakrzewski, A. J., &Kłębukowska, L. (2023). Prevalence and antibiotic resistance of *Bacillus* sp. isolated from raw milk. *Microorganisms*, *11*(4), 1065.

Agarwal, A., Awasthi, V., Dua, A., Ganguly, S., Garg, V., &Marwaha, S. S. (2012). Microbiological profile of milk: impact of household practices. *Indian Journal of Public Health, 56*(1), 88-94.

Anagboso, M., Ohaebuka, C., Mbah, E., Osuala, O., Daokoru-Olukole, C., Agedah, E., Onu, E., Nwankwo, G., Okafor, F., &Okonko, I. (2024).Microbial contamination and antibiotic resistance in selected yoghurt brands in Elele, Rivers State, Nigeria.*Covenant Journal of Physical and Life Sciences*, 12(2). Retrieved from https://journals.covenantuniversity.edu.ng/index.php/cjpls/article/view/4521

Attah, F., Abalaka, M. E., Jesse, I. A., Garba, D. E., & Emmanuel, A. (2021).*Bacteriological quality of raw cow's milk sold in Minna Central Market, Niger State, Nigeria*. *International Journal of Pathogen Research*, 6(1), 29–35. https://doi.org/10.9734/ijpr/2021/v6i130153

Collins, Á. B., Floyd, S., Gordon, S. V., & More, S. J. (2022). Prevalence of *Mycobacterium bovis* in milk on dairy cattle farms: An international systematic literature review and meta-analysis. *Tuberculosis (Edinburgh, Scotland), 132*, 102166.https://doi.org/10.1016/j.tube.2022.102166

Edema, M. O., &Akingbade, O. A. (2007). Incidence of spore-forming bacteria in unsweetened evaporated milk brands in Nigeria. *Nigerian Food Journal*, *25*(1), 138-145.

Eltokhy, H., Abdelsamei, H., El Barbary, H., &Nassif, M. (2021).Prevalence of some pathogenic bacteria in dairy products.*Benha Veterinary Medical Journal, 40*(2), 51-55. doi: 10.21608/bvmj.2021.90181.1461

Kahla, I. B., Boschiroli, M. L., Souissi, F., Cherif, N., Benzarti, M., Boukadida, J., &Hammami, S. (2011). Isolation and molecular characterisation of *Mycobacterium bovis* from raw milk in Tunisia.*African Health Sciences, 11*, 2-5.

Koski, L., Kisselburgh, H., Landsman, L., Hulkower, R., Howard-Williams, M., Salah, Z., ...& Nichols, M. (2022). Foodborne illness outbreaks linked to unpasteurised milk and relationship to changes in state laws–United States, 1998–2018. *Epidemiology & Infection*, *150*, e183.

Ledenbach, L. H., & Marshall, R. T. (2009)."Microbiological Spoilage of Dairy Products." In W. H. Sperber& M. P. Doyle (Eds.), *Compendium of the Microbiological Spoilage of Foods and Beverages* (pp. 41–67). Springer.

Li, K. (2022). An overview of microbial contamination in milk and dairy products.*Global Journal of Dairy Farming and Milk Production, 7*(2), 1–2.

Mariam, S. H. (2021). Isolation and Characterization of Gram-Negative Bacterial Species from Pasteurized Dairy Products: Potential Risk to Consumer Health. *Journal of Food Quality*, *2021*(1), 8876926.https://doi.org/10.1155/2021/8876926

221 Martin, N. H., Evanowski, R. L., &Wiedmann, M. (2023).Invited review: Redefining raw milk
222 quality Evaluation of raw milk microbiological parameters to ensure high-quality
223 processed dairy products. *Journal of Dairy Science*, *106*(3), 1502-1517.

224 Pal, M., Mulu, S., Tekle, M., Pintoo, S. V., &Prajapati, J. (2016). Bacterial contamination of
225 dairy products.*Beverage and Food World, 43*(9), 40-43.

226 Peng, Z., Li, Y., Yan, L., Yang, S., & Yang, D. (2023). Correlation Analysis of Microbial
227 Contamination and Alkaline Phosphatase Activity in Raw Milk and Dairy
228 Products. *International Journal of Environmental Research and Public Health*, *20*(3),
229 1825. https://doi.org/10.3390/ijerph20031825

230 Svensson, B., Eneroth, Å. S. A., Brendehaug, J., Molin, G., &Christiansson, A.
231 (2000).Involvement of a pasteurizer in the contamination of milk by *Bacillus cereus* in a
232 commercial dairy plant.*Journal of Dairy Research, 67*(3), 455-460.

233 Tan, S. F., Chin, N. L., Tee, T. P., &Chooi, S. K. (2020).Physico-Chemical Changes,
234 Microbiological Properties, and Storage Shelf Life of Cow and Goat Milk from Industrial
235 High-Pressure Processing.*Processes, 8*(6), 697.https://doi.org/10.3390/pr8060697

236 Velázquez-Ordoñez, V., Valladares-Carranza, B., Tenorio-Borroto, E., Talavera-Rojas, M.,
237 Varela-Guerrero, J.A., Acosta-Dibarrat, J., Puigvert, F., Grille, L., Revello, Á.G.,
238 &Pareja, L. (2019).Microbial Contamination in Milk Quality and Health Risk of the
239 Consumers of Raw Milk and Dairy Products. *Nutrition in Health and Disease - Our*
240 *Challenges Now and Forthcoming Time*.

241 Yobouet, B. A., Kouamé-Sina, S. M., Dadié, A., Makita, K., Grace, D., Djè, K. M., &Bonfoh, B.
242 (2014).Contamination of raw milk with *Bacillus cereus* from farm to retail in Abidjan,
243 Côte d'Ivoire and possible health implications.*Dairy Science & Technology, 94*, 51-60.

244

245