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Preservative potentials and stability of bacteriocin-producing lactic acid bacteria of dairy origins

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Abstract:

Background: Lactic acid bacteria (LAB) from dairy sources are known to produce bacteriocins with promising antimicrobial properties. The variations in their preservative effectiveness and stability under different environmental conditions create a gap in knowledge. This study aimed to produce bacteriocin and determine their stability properties of bacteriocin isolated from lactic acid bacteria indigenous to selected fermented diary (cheese and 'Nunu') within Ilorin metropolis.
Methodology: Isolation and identification of bacteriocin-producing lactic acid bacteria (LAB) from fermented dairy products and bacteriocin purification, were carried out by standard methods. Bacteriocin stability tests were performed and characterized by heat resistance, sensitivity to pH and proteolytic enzyme by the method described by Gautam and Sharma. Bio-preservation efficacy of bacteriocin was evaluated through microbial load determination of the food products after treatment with purified bacteriocin, with and without refrigeration. Molecular identification of the bacteriocin-producing LAB was determined by 16S rRNA sequencing.
Results: Four LAB were isolated from the food products and phenotypically identified as *Lactobacillus* spp and *Streptococcus* spp. The bacteriocin-producing LAB were identified by 16s RNA sequencing as *Lactobacillus fermentum* strain TSGB1241, *Lactococcus fermentum* strain DMF18, *Lactococcus lactis* subsp *cremoris* and *Pediococcus pentosaceus* SL4. The antibacterial activity of bacteriocin produced by the LAB was affected by an increase temperature and maximum activity was recorded at acidic pH (2.0-4.0), which indicates its potential use in acidic food. The antibacterial activity was completely lost during treatment with proteolytic enzyme (pepsin). The preservative test showed the potential of refrigerated bacteriocin to reduce microbial load that may contaminate stored food products.
Conclusion: Bacteriocin produced from cheese and 'Nunu' offer bio-preservative efficacy and provide stability to intrinsic and extrinsic factors that can affect food spoilage. This bacteriocin offers natural and safe and effective preservation to foods products.

Keywords: Fermented diary; Lactic acid bacteria; preservatives; Stability; Bacteriocin

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Potentiel de conservation et stabilité des bactéries lactiques productrices de bactériocines d'origine laitière

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Résumé:

Contexte: Les bactéries lactiques (BAL) d'origine laitière sont connues pour produire des bactériocines aux propriétés antimicrobiennes prometteuses. Les variations de leur efficacité et de leur stabilité en tant que conservateurs dans différentes conditions environnementales créent un manque de connaissances. Cette étude visait à produire des bactériocines et à déterminer leurs propriétés de stabilité. Ces bactériocines ont été isolées de bactéries lactiques indigènes de certains produits laitiers fermentés (fromage et «Nunu») de la métropole d'Ilorin.
Méthodologie: L'isolement et l'identification des bactéries lactiques (BAL) productrices de bactériocines à partir de produits laitiers fermentés, ainsi que la purification des bactériocines, ont été réalisés selon des méthodes standard. Des tests de stabilité des bactériocines ont été effectués et caractérisés par leur thermorésistance, leur sensibilité au pH et leur activité enzymatique protéolytique, selon la méthode décrite par Gautam et Sharma. L'efficacité de la bactériocine en tant que biopréservatrice a été évaluée par la détermination de la charge microbienne des produits alimentaires après traitement avec la bactériocine purifiée, avec et sans réfrigération. L'identification moléculaire des BAL productrices de bactériocines a été déterminée par séquençage de l'ARNr 16S.
Résultats: Quatre bactéries lactiques (BAL) ont été isolées des produits alimentaires et identifiées phénotypiquement comme appartenant aux genres *Lactobacillus* et *Streptococcus*. Les BAL productrices de bactériocine ont été identifiées par séquençage de l'ARN 16S comme étant *Lactobacillus fermentum* souche TSGB1241, *Lactococcus fermentum* souche DMF18, *Lactococcus lactis* subsp. *cremoris* et *Pediococcus pentosaceus* SL4. L'activité antibactérienne de la bactériocine produite par les BAL était influencée par l'augmentation de la température et une activité maximale a été observée à pH acide (2,0-4,0), ce qui indique son potentiel d'utilisation dans les aliments acides. L'activité antibactérienne était totalement abolie lors d'un traitement à la pepsine. Le test de conservation a démontré le potentiel de la bactériocine réfrigérée pour réduire la charge microbienne susceptible de contaminer les produits alimentaires stockés.
Conclusion: La bactériocine produite à partir de fromage et de «Nunu» présente une efficacité de biopréservation et assure une stabilité face aux facteurs intrinsèques et extrinsèques susceptibles d'altérer les aliments. Cette bactériocine offre une conservation naturelle, sûre et efficace des produits alimentaires.

Mots-clés: Produits laitiers fermentés; Bactéries lactiques; Conservateurs; Stabilité; Bactériocine

Introduction:

Antimicrobial peptides (AMPs) are important component that serve as one of the earliest defense mechanisms against invading pathogens (1). These peptides exhibit strong potential as antimicrobial against a wide range of microorganisms, which make them a promising option for the development of novel therapeutic agents. In contrast to most conventional antibiotics, AMPs commonly act by disrupting microbial cell membranes, forming transmembrane pores, and in some cases enhancing host immune responses through immunomodulatory functions (2).

Among AMPs, bacteriocin are the most studied group. Their preservative potentials as antimicrobial largely depends on their ability to associate with and destabilize bacterial cell membranes or cell walls. Typically, AMPs possess an overall positive charge and a high proportion of hydrophobic amino acids, which enables selective attraction to the negatively charged surfaces of bacterial membranes. Once bound, AMPs disrupt membrane integrity through non-enzymatic mechanisms (3).

A major advantage of AMPs is their selective toxicity, as effective antimicrobial peptides must exhibit minimal harm to host mammalian cells. Structural and functional differences between microbial and mammalian membranes including lipid composition, membrane potential, polarity, and organization and contribute to this selectivity and influence the diverse mechanisms of action observed among AMP classes (4). Also, several AMPs demonstrate diverse antimicrobial and immunological activities, suggesting their importance as tools in biomedical applications.

Beyond their direct antimicrobial effects, AMPs can modulate immune responses, which further enhances their therapeutic potential. These peptides offer multiple advantages over traditional antibiotics, including broad-spectrum activity, low propensity for resistance development, synergistic effects with existing antibiotics, and the ability to neutralize endotoxins and regulate immune function (5). AMPs can also interfere with various intracellular processes such as cell wall synthesis, protein production, and nucleic acid replication (6) as well as inhibit formation of bacterial biofilms (7). Additionally, their immunomodulatory roles allow them to regulate inflammation and mitigate septic responses during infection.

Lactic acid bacteria (LAB) are group of Gram-positive, non-spore-forming rods, cocci, and cocco-bacilli, that produces lactic acid as a major product while making use of carbohydrates during fermentation process. LAB are lar-

gely employed for the processing of many fermented food products and beverages. It is well known that LAB, which contribute more to the properties of foods, mediate the fermentation process and may also exhibit antibacterial activity against clinical pathogens. These bacteria not only produce lactic acid as an end product of carbohydrate catabolism but can also produce organic substances that contribute to the flavor and aroma; aiding unique organoleptic characteristics to the products (8). LAB exopolysaccharide (EPS) is economically important because it can impart functional effect to foods and confer beneficial health effects to the consumer.

Lactic acid bacteria are normal, physiological flora of the mouth, intestines and female genital tract. The *Lactobacillus* genus is one of the most important genera in the group of LAB. *Lactobacillus* strains are Gram-positive, catalase-negative, non-spore-forming and non-motile bacilli (9). Traditional and molecular techniques have successfully been used to divide bacteria belonging to the LAB family into the following genera; *Lactobacillus, Streptococcus, Lactococcus, Enterococcus, Melissococcus, Tetragenococcus, Vagococcus, Trichococcus, Carnobacterium, Desemzia, Leuconostoc, Weisella* and *Pediococcus* (10). Gram-positive bacteria belonging to the phylum Actinobacteria, such as the genera *Aerococcus, Microbacterium, Propionibacterium* and *Bifidobacterium* also produce lactic acid.

The antibacterial peptides/bacteriocin produced by *Bacillus safensis* strain MK-12 isolated from waste dump soil have been characterized and optimized by Sajid et al., (11). These bacterial isolates were screened for antagonistic activity against a set of American Type Culture Collections (ATCC) and local multi-drug-resistant human pathogenic bacterial strains and discovered that the soil were reservoir of these strains exhibiting antibacterial activities and could be a promising source of antimicrobial compounds to tackle against resistant bacteria in future. Therefore, this study aimed to identify bacteriocin from locally selected fermented diary ('Nunu' and cheese) and evaluate their stability and bio-preservative efficacies against some selected drug-resistant pathogens and food spoilage bacteria.

Materials and method:

Study setting:

The study is conducted in the Department of Microbiology, Faculty of Life Sciences, University of Ilorin, Ilorin, Nigeria. The study area is located at approximately latitude 8.479 9° N and longitude 4.5418° E within the University.

Collection and isolation of Lactic Acid Bacteria from selected dairy samples:

Fermented dairy products ('Nunu' and cheese) were purchased at the University kiosk, in the early hour of the day, transported in ice-bag and preserved in the refrigerator before microbial analysis. Samples were serially diluted in sterile distilled water up to 10^{-5} folds, and 0.5ml from 10^{-3} and 10^{-5}dilution factors were plated on MRS agar using the pour plating method. The plates were then incubated anaerobically in air-tight anaerobic jar at 37^0C for 48 hours. Colonies were randomly picked and sub-cultured on MRS agar and incubated anaerobically to obtain pure culture.

Preliminary screening for the identification of the lactic acid bacteria:

The isolated lactic acid bacteria were screened by their microscopic, morphological and biochemical features carried out according to the descriptions in the Bergey's Manual of Determinative Bacteriology (12).

Tests organisms*:*

The test bacteria used to evaluate the microbial effects of the LAB include *Klebsiella pneumoniae*, methicillin-resistant *Staphylococcus aureus*, *Escherichia coli* ATC 25922, methicillin-sensitive *Staphylococcus aureus* 25923, *Salmonella* Typhi*, Enterococcus faecalis, Bacillus megaterium, Serratia marcescens, Citrobacter freundii* and *Staphylococcus aureus* ATCC 25913, which were obtained from the Department of Microbiology, University of Ilorin, Nigeria.

Stability tests for LAB producing bacteriocin:

Bacteriocin from the LAB was purified by precipitation of the bacteria supernatants in ammonium sulphate followed by dialysis to remove excess salt. The stability test of the bacteriocin for heat resistance, sensitivity to pH and proteolytic enzymes was performed according to the method described by Gautam and Sharma (13).

Heat resistance:

Aliquots (5ml) of partially purified bacteriocin were heated at 50^0C, 75^0C, 100^0C in a water bath and at 121^0C in an autoclave for 15 minutes. The treated samples were tested for antibacterial activity against the indicator bacterial strains.

pH sensitivity:

Two and a half (2.5ml) ml aliquots of

the partially purified bacteriocin was taken in a sample bottle and the pH of the contents were adjusted to pH 2, 4, 7 and 9 separately, using either diluted NaOH or HCl (1M NaOH solution). After allowing the samples to stand at room temperature for 2 hours, the antimicrobial activity was assayed according to Fugaban et al., (14).

***Sensitivity to proteolytic enzymes**:*

The LAB supernatant fluid was treated for 1 hour at 37^0C in Pepsin (Sigma) at final concentration of 1 mg/ml. The mixtures were heated in boiling water for 3 minutes to denature the enzymes, before testing the bacteriocin activity.

Bio-preservation potential bacteriocin for food products

Enumeration and isolation of microorganisms at different preservation method:

The microbial loads of the food products (meat and cheese) obtained fresh from the University of Ilorin kiosk were evaluated by four different forms of treatment at 24 hours interval; (i) samples of food products were trea ted with 5% bacteriocin (obtained by diluting 5 ml of the purified bacteriocin in 100 ml of distilled water); (ii) samples were treated with 5% bacteriocin and refrigerated; (iii) samples of the food products were refrigerated only; and (iv) samples of food products had no form of treatment. Enumeration and isolation of the microbial load were carried out at an interval of 24 hours.

Determination of microbial load:

The microbial load of the food products at 24 hours interval on every stage and treatment was carried out by the serial dilution of the food samples from 10^{-1} to 10^{-6} using 1ml of meat and cheese samples for the various treatment and 200µl of samples plated unto nutrient agar plates and incubated at 37°C for 24 hours. The numbers of colonies in duplicate were counted using a digital colony counter to determine the mean (±SD) microbial loads in the sample. The microbial loads of bacteriocin-treated samples were compared with non-treated control samples.

***Characterization of bacterial isolates by 16S rRNA sequencing**:*

Further characterization of the isolates by molecular techniques for better taxonomical data was done using 16s rRNA amplification and Sanger's sequencing, followed by bioinformatic analysis and phylogenetic tree construction. Using the sequence alignment generated, the phylogenetic tree was constructed using the neighbor joining method while maximum composite likelihood method was used to compute evolutionary distance with the bioinformatics software Mega X (15).

Data analysis:

Results were analyzed by analysis of variance (ANOVA) followed by Dunnett's *t*-test. The Statistical Package for the Social Sciences (SPSS, version 26.0) was used to determine the mean and standard deviation of the microbial loads for each sample and probability was accepted at $p \leq 0.05$ significance.

Results:

Isolation and identification of lactic acid bacteria (LAB):

A total of four LAB were isolated based on their morphological characteristics from the 'Nunu' and cheese samples. They were Gram-positive, rod and cocci shaped. The microscopic, morphological and biochemical features of the LAB isolates are presented in Table 1.

Table 1: Microscopic morphology and biochemical characteristics of isolated Lactic Acid Bacteria

Isolates	Gram staining	Morphology	Glucose	Sucrose	Fructose	Dextrose	Maltose	Lactose	Spore Formation	Indole	Methyl Red	Citrate	Catalase	Starch hydrolysis	Oxidase	Oxygen relationship	TSI			Probable identity
																	1	2	3	
M1	+ve	Rod, cream, circular dull, entire	+/+	+/+	+/-	+/-	+/-	+/+	-	-	-	+	-	+	-	FA	L, G, S	-	A	*Lactobacillus* sp
M2	+ve	Rod, cream, irregular, dull, undulate	+/-	+/-	+/-	+/-	+/-	+/+	-	-	-	-	-	-	-	FA	L	-	A	*Lactobacillus* sp
M3	+ve	Cocci, cream, circular, dull, undulate	+/+	+/+	-/-	+/-	+/-	+/+	-	-	-	+	-	-	-	FA	L, G, S	-	A	*Streptococcus*
M4	+ve	Cocci, white, circular, glistering, entire	+/+	+/-	+/-	+/-	+/-	+/+	-	-	-	-	-	+	-	FA	L & G	-	A	*Streptococcus*

TSI = triple sugar iron test (1- gas production, 2- H_2S production, 3- glucose-sucrose and lactose), +/+ = Acid and Gas producer**;** +/- = Acid producer only**;** -/- = No Acid and Gas produced**;** A= Acid producer only**; -** =Negative

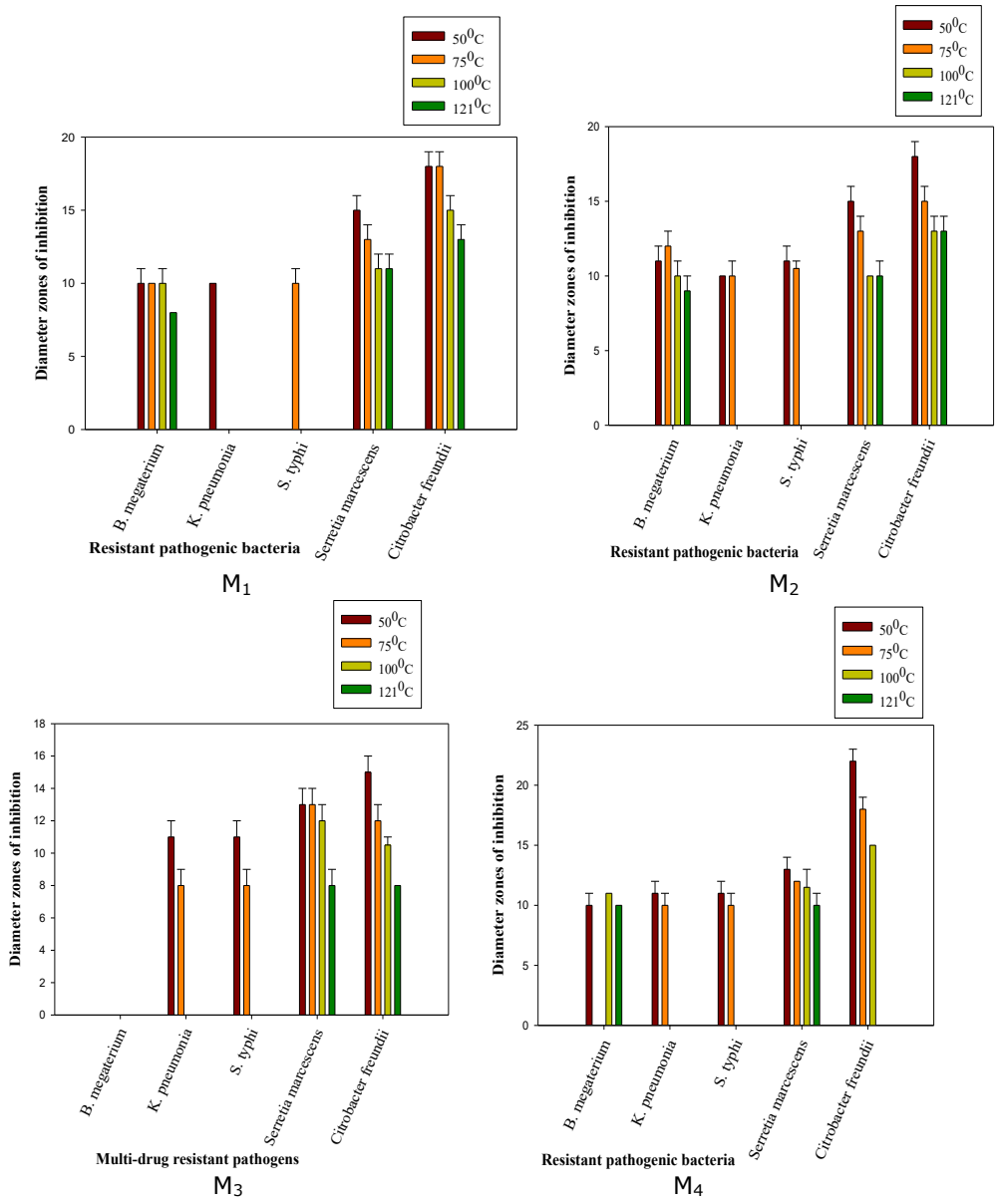


Fig 1: Antibacterial activity of heat-treated partially purified bacteriocins against resistant pathogenic bacteria

Stability testing of bacteriocin-producing LAB:

Effect of heat treatment on bacteriocin*:*

The results showed that bacteriocins produced by the LAB (M_1, M_2, M_3 and M_4) exhibited heat stability at different temperature with the highest at 50^0C, and also exhibited potent antimicrobial activity against *Serratia marcescens*. However, it was observed that there was a reduction in the antimicrobial activity as the temperature increased (Fig 1).

Effect of pH treatment on bacteriocin:

Results show that bacteriocins produced by LAB are more potent at low pH with little or no activity as the pH increased. High antibacterial activity was recorded at pH 2 and pH 4 with no antibacterial activity at pH 9 (Fig 2).

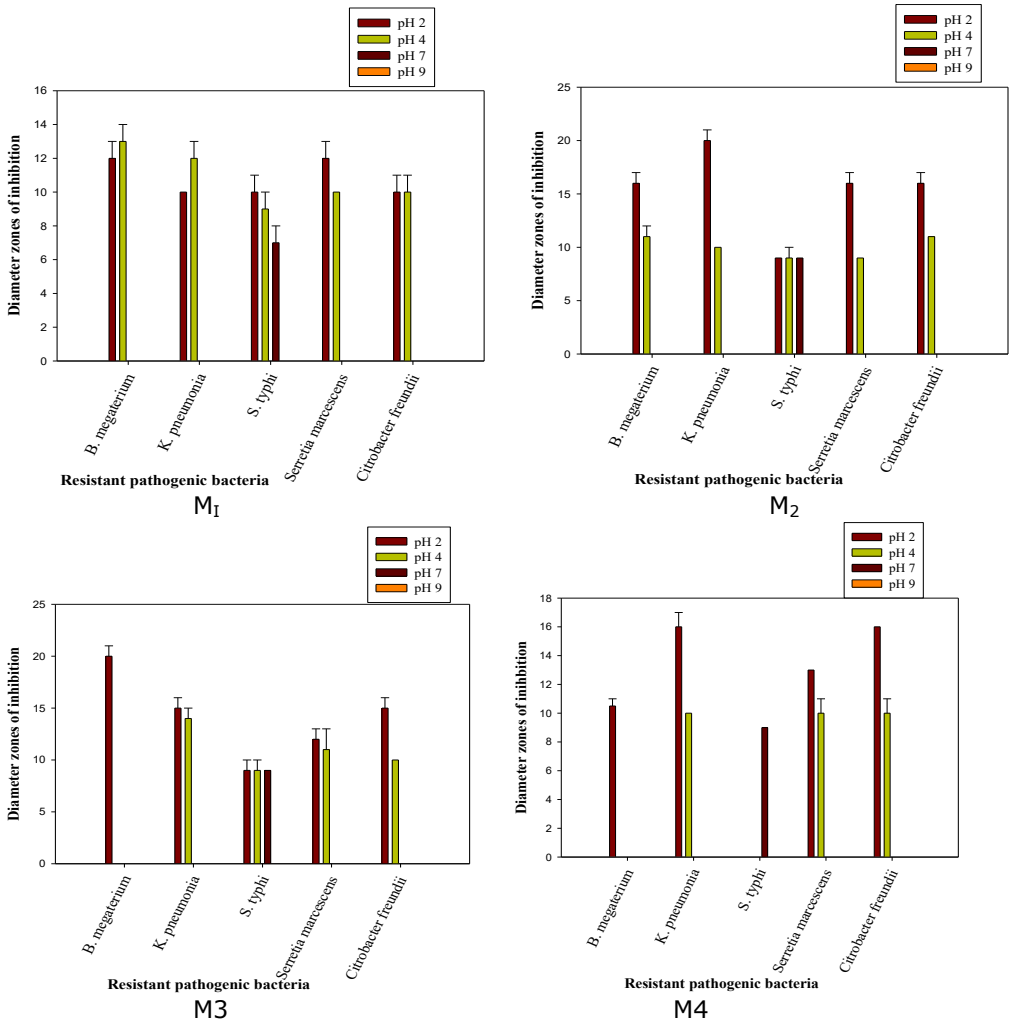


Fig 2: Antibacterial activity of partially purified bacteriocins at different pH against resistant pathogenic bacteria

Sensitivity profile of bacteriocin-producing LAB to proteolytic enzyme (pepsin):

As a result of protein nature of bacteriocin, all purified bacteriocin obtained was fully inactivated (fully sensitive) by proteolytic enzyme, pepsin, hence all the test bacteria were not inhibited (Table 2).

Preservative effect of bacteriocin produced by LAB on cheese and meat:

There was a fairly reduction in microbial load of the food samples subjected to the treatment A (bacteriocin) when compared to other treatment regimen. Treatment B (bacteriocin and refrigeration) showed the lowest microbial load. There was an increase in microbial load in the food products subjected to the treatment of refrigeration only (Treatment C). The food samples in group D (no treatment) had the highest in microbial load as presented in Table 3

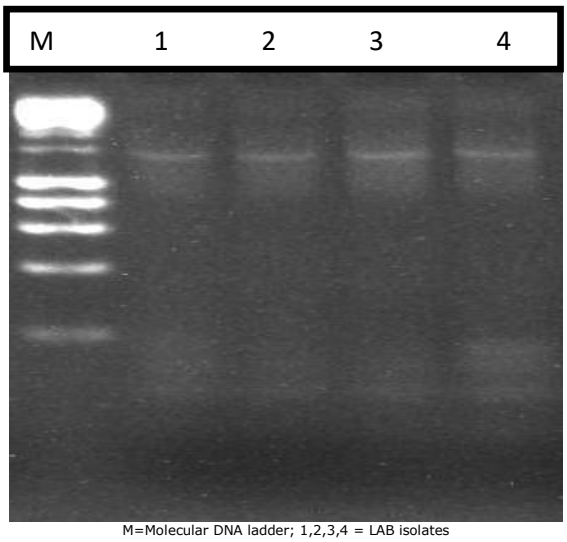
Molecular identification of bacteriocin-producing LAB:

Plate 1 shows the amplified 16s rRNA and DNA molecular ladder, and Fig 1 shows the phylogenetic tree of the isolates. The results from the molecular characterization of the bacteriocin-producing LAB (M_1, M_2, M_3 and M_4) are shown in Table 4.

The four isolates were identified as *Lactobacillus fermentum* strain TSGB1241 for M_1, *Lactobacillus fermentum* strainDMF18 for M_2, *Lactococcus lactis* subsp. *cremoris* C4 DNA for M_3 and *Pediococcus pentosaceus* SL4 for M_4.

Table 2: Sensitivity of bacteriocin-producing LAB to pepsin

Test isolate	**Treated isolated lactic acid bacteria**			
	M1	**M2**	**M3**	**M4**
Salmonella Typhi	Sensitive	Sensitive	Sensitive	Sensitive
Citrobacter freundii	Sensitive	Sensitive	Sensitive	Sensitive
Methicillin resistant *Staphylococcus aureus*	Sensitive	Sensitive	Sensitive	Sensitive
Escherichia coli ATCC 25922	Sensitive	Sensitive	Sensitive	
Bacillus megaterium	Sensitive	Sensitive	Sensitive	Sensitive
Enterococcus faecalis	Sensitive	Sensitive	Sensitive	Sensitive
Serratia marcescens	Sensitive	Sensitive	Sensitive	Sensitive
Klebsiella pneumoniae	Sensitive	Sensitive	Sensitive	Sensitive
MSSA ATCC 25923	Sensitive	Sensitive	Sensitive	Sensitive



M=Molecular DNA ladder; 1,2,3,4 = LAB isolates

Plate 1: Gel electrophoresis picture of amplified 16 sRNA of isolated lactic acid bacteria strains with DNA ladder

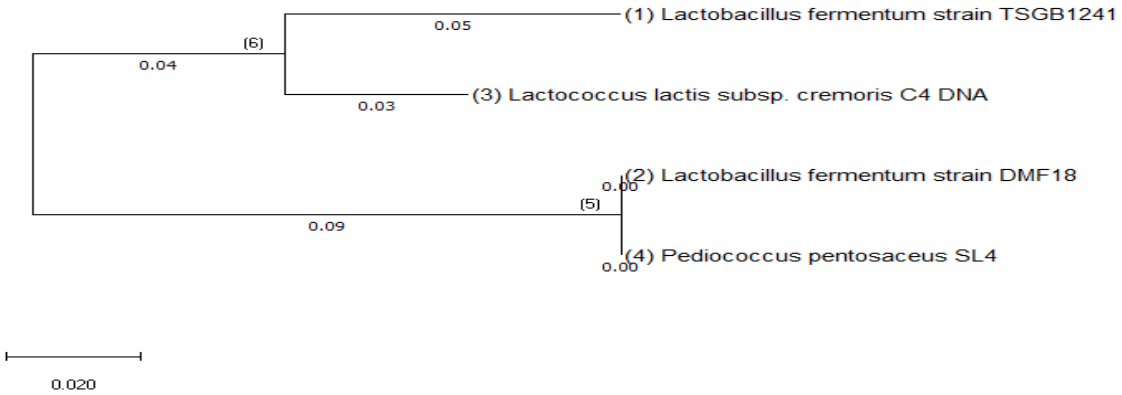


Fig 1: Phylogenetic relationship of identified lactic acid bacteria with those on NCBI

Table 3: Evaluation of microbial loads of food products from preservative effect of LAB bacteriocin on cheese and meat samples

Exposure time (hours)	Mean (±SD) microbial load (x10^7 CFU/ml) in meat after treatment				Mean (±SD) microbial load (x10^7 CFU/ml) in cheese after treatment			
	A	B	C	D	A	B	C	D
24	15±1.41^a	40±0.00^b	135.5±2.12^c	140.5±2.12	32±0.71^b	15±1.41^{bc}	50±7.07^b	30±0.00
48	30±2.82^a	16±2.83^a	120.5±2.12^c	4±1.41	40±7.07^c	3.5±2.12^a	30±14.14^{ab}	25±4.24
72	20±7.07^a	50±2.83^c	80.5±7.78^b	250.5±28.99	25±2.83^b	20.5±3.54^c	8±5.66^a	80±8.49
96	31±0.00^a	43±1.41^b	50±0.00^a	125.5±0.71	20±0.00^{ab}	12.5±0.71^{abc}	11±1.41^a	115±0.00
110	30±7.07^a	17±1.41^a	84.5±13.44^b	TNTC	10±4.24^a	8±4.24^{ab}	16.5±0.71^a	TNTC

A = Treatment with bacteriocin only; B = Bacteriocin and refrigeration; C = Refrigeration only; D = Without bacteriocin and refrigeration; TNTC = Too numerous to count
Note: Alphabets in the superscript are statistically different at 0.05 probability level

Table 4: Molecular identification of lactic acid bacteria (M_1, M_2, M_3 and M_4)

Organism name	Maximum score	E-value	Identity (%)	Accession number
Lactobacillus fermentum strain TSGB1241	1646	0.0	95.75	MN255729.1
Lactobacillus fermentum strain DMF18	1105	0.0	92.08	MH782089.1
Lactococcus lactis subsp. cremoris C4 DNA	728	0.0	81.38	AP018499.1
Pediococcus pentosaceus SL4	710	0.0	83.82	CP006854.1

Discussion:

The use of antimicrobial peptide produced by lactic acid bacteria for bio-preservation is a relatively new concept to eliminate or control the spread of pathogenic or spoilage bacteria in food (16). This study has successfully isolated bacteriocin-producing LAB from lactic acid bacteria isolated from dairy products with potential for bio-preservation. *Lactobacillus* and *Streptococcus* represent the genera of bacteria capable of producing bacteriocin. The morphological and biochemical features of the LAB demonstrated in this study are in line with the previous study by Soltan et al., (9) who also identified these genera of bacteria capable of producing bacteriocin.

Heat stability suggested that bacteriocins produced by LAB in this study are able to tolerate different heat treatment (temperature). This is similar to the observation made by Wu et al., (17) who purified and characterize bacteriocin produced by a strain of *Lacticaseibacillus rhamnosus* ZFM216 and also observed stability of the bacteriocin at different temperature (17). However, the observation that antibacterial activity reduced with increase in temperature may be attributed to the fact that high temperature partially affects some components of bacteriocin. Bacteriocin are proteinaceous in nature and protein are denatured by high temperature. The antimicrobial activity of the bacterial isolates studied were observed to have maximum activity at acidic pH (2.0–4.0) and a reduction in antibacterial activity at pH 7 and no activity at pH 9. This result suggests that such bacteriocins could be used in acidic food products like fruit juices and food products that has neutral pH. This result is in consonance with the findings of Singh et al*.,* (8), whose study showed maximum bactericocin activity at pH 2-6. High antimicrobial activity was detected at low pH in this study, as also shown by Araújo et al*.,* (19), but contrast the study of Abanoz and Kundholu (20), who reported in a study that bacteriocin activity are maintained over a wide range of temperature.

Also, the bacteriocin treated with proteolytic enzyme (pepsin) lost antibacterial potential, implying that proteolytic enzyme was able to degrade the bacteriocin. Soltani et al., (21) reported similarly that bacteriocin from Gram-positive and Gram-negative bacteria have tendency of degrading bacteriocin (21). This indicates that bacteriocins are proteins. The food products (cheese and meat) treated with bacteriocin had a reduced microbial load when compared to the food products that were refrigerated alone. This is because food spoilage organism such as mesophilic bacteria can be inhibited by refrigeration.

The molecular analysis of the LAB isolated from the food products revealed M1 to be *Lactobacillus fermentum* strain TSGB 1241, M2 to be *Lactococcus fermentum* strain DMF 18, M2 to be *Lactococcus lactis* subsp. *cremoris* and M4 to be *Pediococcus pentosaceus* SL4. The four LAB strains isolated were identified using 16S rRNA sequencing followed by BLAST analyzing. Sanger sequencing by 16S rRNA is a good option due to the possession of proper gene size and availability of a large number of sequences in databases for comparison. The phylogenetic tree of the characterized bacteriocin producing LAB constructed revealed the closest identity to those in the GenBank through neighbour-joining method (22).

Conclusion:

This study identified bacteriocins from four LAB which exhibited stability and preservative potential against resistant bacterial pathogens in meat and cheese. it is recommended that bacteriocin-producing LAB be considered as alternative to combat resistant pathogenic bacteria in addition being used as natural, safe and effective bio-preservatives.

Contribution of authors:

SAO conceptualized and planned the methodology; OIO wrote the manuscript and was involved in conduct of the study; OOG analyzed and presented the result of the study; and STA awas involved in conducting laboratory study and data collection. All the authors contributed to manuscript and approved the manuscript submitted for publication.

Conflict of interest:

Authors declare that no known conflict of interest or personal relationships that could have influence the work reported in this paper.

Data availability:

Data are available upon request from the corresponding author of this paper.

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References:

1. Duarte-Mata, D. I., and Salinas-Carmona, M. C. Antimicrobial peptides´ immune modulation role in intracellular bacterial infection. Front Immunol. 2023; 14: 1119574. doi: 10.3389/fimmu.2023.1119574.
2. Reddy, K. V. P., Yedery, R. D., and Aranha, C. Antimicrobial peptides: An emerging category of therapeutic agents. Curr Opin Biotech. 2004; 15 (5): 316–322. https://doi.org/10.1016/j.ijantimicag.2004.09.005
3. Li, H., Niu, J., Wang, X., et al. The Contribution of Antimicrobial Peptides to Immune Cell Function: A Review of Recent Advances. Pharmaceutics. 2023; 15(9):2278.doi: 10.3390/pharmaceutics15092278
4. Wang, G., Mishra, B., Lau, K., et al. Antimicrobial peptides in 2014. Pharmaceuticals. 2015; 8 (1): 123-150. doi: 10.3390/ph8010123.
5. Mishra, B., Reiling, S., Zarena, D., et al. Host defense antimicrobial peptides as antibiotics: Design and application strategies. Curr Opin Chem Biol. 2017; 38: 87–96. doi: 10.1016/j.cbpa.2017.03.014
6. Wang, Z., and Wang, G. APD3: The Antimicrobial Peptide Database as a Tool for Research and Education. Nucl Acid Res. 2016; 44: D1087-D1093. https://doi.org/10.1093/nar/gkv1278
7. Heruka De Zoysa, G., Cameron, A. J., Hegde, V. V., et al. Antimicrobial Peptides with Potential for Biofilm Eradication: Synthesis and Structure Activity Relationship Studies of Battacin Peptides. J Med Chem. 2015; 58: 625–639. doi: 10.1021/jm501084q
8. Gupta, R., Jeevaratnam, K., and Fatima, A. Lactic Acid Bacteria: Probiotic Characteristic, Selection Criteria, and its Role in Human Health—A Review. Int J Environ Res Publ Health. 2018; 5 (10): 411-424
9. Soltan-Dallal, M. M., Zamaniahari, S., Davoodabadi, A., et al. Identification and characterization of probiotic lactic acid bacteria isolated from traditional Persian pickled vegetables. GMS Hyg Infect Contr. 2017; 12: 15. doi: 10.3205/dgkh000300.
10. Hammes, W. P., and Hertel, C. The Genera Lactobacillus and Carnobacterium. In: Dworkin, M., Falkow, S., Rosenberg, E., Schleifer, K. H., and Stackebrandt, E (Eds.). The Prokaryotes. 3rd edn., Vol. 4: Bacteria: Firmicutes, Cyanobacteria, Springer, New York. 2006: 320-403. doi: 10.1007/0-387-30744-3_10
11. Sajid, I., Muhammad, B., Farida, R., et al. Screening, Characterization and Optimization of antibacterial peptides, produced by *Bacillus safensis* strain MK-12 isolated from waste dump soil KP. Pakistan. 2018; doi.org/10.1101/308205.
12. Bergey, D. H., and Holt, J. G. Bergey's Manual of Determinative Bacteriology. 9th edn. Philadelphia: Lippincott Williams & Wilkins. 2000.
13. Gautam, N., and Sharma, N. Bacteriocin: safest approach to preserve food products. Indian J Microbiol. 2009; 49(3): 204–211. doi: 10.1007/s12088-009-0048-3.
14. Fugaban, J. I. I., Vazquez Bucheli, J. E., Holzapfel, W. H., et al. Characterization of Partially Purified Bacteriocins Produced by *Enterococcus faecium* Strains Isolated from Soybean Paste Active Against *Listeria* spp. and Vancomycin-Resistant Enterococci. Microorganisms. 2021;9 (5):1085. doi: 10.3390/microorganisms9051085
15. Kumar, S., Stecher, G., Li, M., et al. MEGAX: Molecular Evolutionary Genetics Analysis across computing platforms. Mol Biol Evol. 2018; 35 (6): 1547-1549. doi: 10.1093/molbev/msy096.
16. Putri, D. A., Lei, J., Rossiana, N., et al. Bio-preservation of Food Using Bacteriocins From Lactic Acid Bacteria: Classification, Mechanisms and Commercial Applications. Int J Microb. 2024: 8723968. doi: 10.1155/ijm/8723968.
17. Wu, D., Dai, M., Shi, Y., et al. Purification and characterization of bacteriocin produced by a strain of *Lacticaseibacillus rhamnosus* ZFM216. Front Microbiol. 2022; 13: 1050807. doi: 10.3389/fmicb.2022.1050807
18. Singh, J. K., Devi, P. B., Reddy, G. B., et al. Biosynthesis, classification, properties, and applications of *Weissella* bacteriocins. Front Microbiol. 2024; 15: 1406904. doi: 10.3389/fmicb.2024.1406904.
19. Araújo, E. S., Pimenta, A. S., Feijó, F. M. C., et al. Antibacterial and antifungal activities of pyroligneous acid from wood of *Eucalyptus urograndis* and *Mimosa tenuiflora*. J Appl Microb. 2018; 124 (1): 85-96. doi: 10.1111/jam.13626
20. Abanoz, H. S., and Kunduhoglu, B. Antimicrobial activity of Bacteriocin produced by *Enterococcus faecalis* KT11 against some pathogens and Antibiotic-resistant bacteria. Korean J Food Animal. 2018; 38 (5): 1064-1079 doi: 10.5851/kosfa.2018.e40.
21. Soltani, S., Zirah, S., Rebuffat, S., et al. Gastrointestinal Stability and Cytotoxicity of Bacteriocins from Gram-Positive and Gram-Negative Bacteria: A Comparative *in vitro* study. Front Microbiol. 2022; 12: 780355. doi: 10.3389/fmicb.2021.780355
22. Elayaraja, S., Annamalai, N., Mayavu, P., et al. Production, purification and characterization of bacteriocin from Lactobacillus murinus AU06 and its broad antibacterial spectrum. Asian Pac Trop Biomed. 2014; 4 (Suppl 1): S305–S311. https://doi.org/10.12980/APJTB.4.2014C537