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Effect of *Salmonella Enterica* Serovar Enteritidison Nisin Gene Expression Induced by *Lactococcuslactis* on Chicken Meat

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CONTAMINATED chicken meat is measured as one of the most significant sources of *Salmonella enterica* serovar Enteritidis (*Se*s E). Using nisin-producer *Lactococcuslactis* (*L. lactis*) is a practical approach to diminish the risk of food-borne pathogens in chicken meat. The existingsurvey was done to assess the effect of *Se*sEon nisin gene expression induced by *L. lactis*on chicken meat. Chicken meat was divided into 4 groups of *L. lactis* control group (BHI media inoculated with 1.5×10^8 CFU/ml *L. lactis*), *Se*s Econtrol group (BHI media inoculated with 1.5×10^5 CFU/ml *Se*s E), *L. lactis* exposure group (BHI media inoculated with 1.5×10^8 CFU/ml *L. lactis*) and finally *Se*s Eexposure group (BHI media inoculated with 1.5×10^5 CFU/ml *Se*s E). Then, pH and protein contents, numbers of bacteria and nisin gene expression were examined. Growth of *Se*s Ein the exposure group has been decreased. *L. lactis* inhibits from severe changes in pH and protein contents of chicken meat. After 4 h of maintenance, amount of nisin gene expression in *L. lactis* subsp. lactis co-culture with *Se*sE was 1.9 times higher than *L. lactis* subsp. lactis mono-culture (P =0.0008). After 48 h maintenance, amount of nisin gene expression in *L. lactis* subsp. lactis mono-culture was 1.1 times higher than *L. lactis* subsp. lactis co-culture with *Se*s E (P =0.042). *Se*s Ecan cause substantial increase in the nisin gene expression and subsequent production of nisin by *L. lactis* subsp. lactis.

Keywords: *Lactococcuslactis*, Nisin, *Salmonella enterica* serovar *enteritidis*, Gene expression, Chicken meat.

Introduction

The lactic acid bacteria (LAB) are anextensive bacteriocin producers microorganisms. LAB are non-spore forming cocci, coccobacilli or rod shapes lactic acid, Gram-positive, CO_2 and ethanol producing bacteria [1-3]. Bacteriocins induced by LAB are predominantly fascinatin gowing totheir long history of safe use. Furthermore, they are measured as Generally Regarded AsSafe (GRAS) products[1-3]. Nisin is the most renowned and GRAS lantibiotic produced by some strains of *Lactococcuslactis* (*L. lactis*) subsp. lactis [4-6]. Nisin is a bacteriocin with bactericidal and bacteriostatic effects towardabundant microorganisms[4-6]. Application of nisin-producing *L. lactis*bacteria as starter in food production guarantees a supplementarysecuritybenefit, sincethey can constrainconceivable contamination by potential food-borne pathogens, including *Salmonella enterica* (*S. enterica*) [7, 8]. Nevertheless, the fruitfuluse of probiotic startersrely on its aptitude to nisinsynthesize in the food [9, 10]. Moreover, construction of littleamounts of nisin in food stuffsmight be unsatisfactory to monitorspoilage bacteria and pathogens [9, 10]. Thus, it is imperative to found anappropriate way to surge the production of nisin in food samples.

S. enteritica is a chief cause of food-borne diseases. *Salmonella enterica* serovar *enteritidis* (*Se*sE) is one of the chief serovars of *S. enterica* subsp. *enterica* which can infect humans, rodents and Galliformes [11,12]. Poultry-meat and derived products are measured a chief source of

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human infection with Salmonella. Chickens can be infected with many diverse serovars of this bacterium. Of these, *Se*sE has boost standing. *Se*s Eis accountable for severe intestinal diseases and food poisoning [11,12].

Microbiological surveysre commended mixed cultures as anappropriateapproach to determine novel bacteriocins or antibiotics [13, 14]. The LAB bacteriocin-producing microorganisms are existingin consort withadditionalbacteria in foods and the foremostperson of bacteriocins is reserve of the growth and survival of pathogens. Thus, the performance of bacteriocin-producing microorganisms in anattendance of virulentmicrobes is an imperativefeature [13, 14]. Thus, an existing survey was accompanied to assess the amount of expression of nisin gene by *L. lactis* subsp. lactis in amalgamation with *Se*sE in chicken meat samples.

Materials and Methods

Moral deliberation

The survey was permitted by the author's academic institute (Endorsement No910641622).

Microorganisms and culture media

The *L. lactis* subsp. lactis (ATCC 11454) was applied as nisin–producing. De Man Rogosa and Sharp (MRS) broth (Merck, Germany) was used for growth of *L. lactis* (37 °C). *Se*s E (PTCC 1709) was cultured in Brain-Herat Infusion medium (BHI, Merck, Germany) at 37°C [7]. Applied bacteria were prepared from the Iranian Research Organization for Science and Technology (IROST, Tehran, Iran).

Study thepattern of growth of bacteria in culture media

Nisin-positive *L. lactis* (1.5×10^8 CFU/mL) was inoculated into BHI broth media contained 1.5×10^8 CFU/mL *Se*sE. BHI media without any pathogenic bacteria were applied as positive control. At that time, BHI broth media were divided into 4 diverse groups of *L. lactis* control group (BHI media inoculated with 1.5×10^8 CFU/ml *L. lactis*), *Se*s E control group (BHI media inoculated with 1.5×10^5 CFU/ml *Se*sE), *L. lactis* exposure group (BHI media inoculated with 1.5×10^8 CFU/ml *L. lactis*) and finally and *Se*s E exposure group (BHI media inoculated with 1.5×10^5 CFU/ml *Se*sE). Exposure groups contained both bacteria but *L. lactis* bacteria were only counted in *L. lactis* exposure group and *Se*sE bacteria were only counted in *Se*sE exposure group. Tubes contained *Se*sE were reserved at 12°C and were microbiologically examined on days 0, 3, 5, and 7 after inoculation. Counting of *Se*s E was done in Salmonella-Shigella (SS) Agar (Merck, Germany).

Bacterial inoculation into specimens

Anentire of 128 parts of chicken breast meat samples (about 100 g each) from green chicken carcasses (those who were raised without antibiotic prescription) after ward the slaughtering was obtained and individually mixed by stomacher. Ice and cool box were applied for sample's transport. Furthermore, Pulsed ultraviolet (UV)-light was used for decontamination of chicken breast meat samples. Breast meat was decorated tobits(10 $cm^2\times5$ mm) with approximately 10 g weight using a sterile knife and cutting board. At that moment, chicken breast meat samples were divided into 4 diverse groups of *L. lactis* control group (chicken breast meat samples inoculated with 1.5×10^8 CFU/ml *L. lactis*), *Se*sEcontrol group (chicken breast meat samples inoculated with 1.5×10^5 CFU/ml *Se*sE), *L. lactis* exposure group (chicken breast meat samples inoculated with 1.5×10^8 CFU/ml *L. lactis*) and finally *Se*s Eexposure group (chicken breast meat samples inoculated with 1.5×10^5 CFU/ml *Se*sE). Exposure groups contained both bacteria but *L. lactis* bacteria were only counted in *L. lactis* exposure group and *Se*s E bacteria were only counted in *Se*sE exposure group. For this purpose, *L. lactis* culture (0.1 ml , 1.5×10^8 CFU/ml) with the greatest constrainaction originated from the preceding survey [7] and *Se*sE (0.1 ml, 1.5×10^5 CFU/ml) were positioned and blowoutcarefully on the superficialshares of chicken meat specimens. All samples were reserved at 12°C and were microbiologically examined on days 0, 3, 5, and 7 after inoculation.

Microbial analysis of chicken meat samples

Microbial counts were performed in triplicate. Sterile peptone (0.1%) dilution was applied for sample dilution. The primary dilutions were organize dusing diluent addition to each sample (10^{-1}). Obtained mixture was blended using Stomacher (Seward Medical, London, UK) for about 1 min. Salmonella enumeration was done using XLD agar (Merck KGaA, Darmstadt, Germany) (37°C for 48 h), while *L. lacctis* enumeration was done using MRS agar (Merck KGaA, Darmstadt, Germany) (30°C for around 48 h in anaerobic circumstances). Mean values of achieved data of 2 Petri dishes were considered.

Study the effects of L. lactis on pH and protein contents of chicken meat samples

Changes in the pH and crude protein of chicken meat samples were analyzed in order to assess the probable corruption of *L. lactis* on chicken meat. The pH of meat was determined using calibrated pH meter (HI 9219, Hanna Instruments; Woonsocket, RI, USA). Protein contents of chicken meat samples were analyzed using the Kjeldahl method according to the Association of Official Analytical Chemists (AOAC) [15].

DNA extraction and nisinA gene detection

Presence of the nisin gene in the *L. lactis* bacteria was examined using the PCR. *L. lactis* bacteria were sub-cultured on MRS broth (37 °C, 48 h). DNA extraction kit (Thermo Fisher Scientific, Germany) was applied for DNA extraction. Technique was performed rendering to the factory instruction. Extracted DNA samples were subjected to quantification by NanoDrop device (NanoDrop, Thermo Scientific, Waltham, USA), qualification (2% agarose gel) and purity checking (A260/A280). PCR was performed by means of thermal cycler (Eppendorf, Germany) rendering the conveyed technique [16]. Nisin structural gene (nisin A gene) was detected in the PCR amplification of *nisA* primers (F: 5′–TCAGGTGCATCACCACGCATTA–3′ and R: 5′–TTACGTGAATACTACAATGACAAGTTGCT–3′ (115 bp)[17]. PCR was finalized using previouslymethod [17].

RNA extraction

Nisin gene expression was examined using the real-time PCR. RNA purification kit (Jena Bioscience, Germany) was applied for RNA extraction rendering the factory guidelines. Extracted RNA samples were subjected to quantification by NanoDrop device (NanoDrop, Thermo Scientific, Waltham, USA) and qualification (1% agarose gel). Extracted RNA was stored at −80 °C until use.

Synthesis of cDNA

Prime Script RT reagent Kit (TaKaRa Biotechnology, Japan) was applied for synthesis of cDNA from 500 ng of extracted RNA.

Nisin gene expression using the real-time PCR

Effect of *Se*sE on nisin gene expression induced by *L. lactis* bacteria was examined using the RT-PCR. RT-PCR reaction was performed by means of the real-time PCR device (Qiagen, Germany). Table 1 illustrates list of primers of the RT-PCR[18]. The *16S rRNA* gene was used as house kipping gene. Procedures were performed rendering beforehand techniques [7, 18, 19]. Primer applied for nisin A gene amplification was designed by means of the Light Cycler probe design software (v1.0; Roche Applied Science, Mannheim, Germany) and synthesized by Eurogentec (Seraing, Belgium). Primer's validity was confirmed by means of the Basic Local Alignment Search Tool (BLAST) of the National Center for Biotechnology Information. NCBI-primer blast facility was applied to check the specificity of primers. The real-time PCR reaction was performed in 10 µl volume including SYBR Green PCR Mastermix (5 µl, Thermo Fisher Scientific, Germany), forward and reverse primers (100 nM of each), cDNA (200 ng) and water. The amplification was included 95 °C for 15 min, followed by 40 cycles of 95 °C for 45 s and at 50 °C for 45 s.

Numerical examination

Tests were performed in triplicates. Data were examined by the SPSS 21.0 (Chicago, USA). Two-way ANOVA and additionally Tukey's tests were perfumed. P level of ≤0.05 was measured as level of meaning.

Results

Table 2 demonstrates the counting *L. lactis* and *Se*sE on chicken meat during the maintenance period in culture media. Numbers of all tested bacteria in all examined groups have been meaning fully amplified up to day 3 of maintenance period ($P \leq 0.05$) with the exception of the *L. lactis* control group ($P > 0.05$). Growth of *Se*sE in the exposure group on days 3 to 7 has been meaning fully reduced ($P \leq 0.05$).

Table 3 displays the numbers of *L. lactis* and *Se*sE on chicken meat throughout the maintenance period. Numbers of all tested bacteria in all examined groups have been meaning fully amplified throughout the maintenance period ($P \leq 0.05$). Growth of *Se*sE in the exposure group on days 3 to 7 has been meaning fully reduced ($P \leq 0.05$).

Table 4 characterizes the pH changes of chicken meat samples inoculated with *L. lactis* during the maintenance period. The mean content of pH in chicken meat samples in *L. lactis* control group was 5.8±0.2 at the beginning of the maintenance period. The mean content of pH of chicken meat samples in *L. lactis* control group has been numerically reduced ($P < 0.05$). The mean content of pH in chicken meat samples in *L.*

lactis control group was 5.0±0.1 at the end of the maintenance period. There were no numerically variance for content of pH amid 5th and 7th days of maintenance in the *L. lactis* control group (P>0.05). The mean content of pH in raw chicken meat samples was 5.9±0.1 at the beginning of the maintenance period. The mean content of pH of raw chicken meat samples has been numerically amplified (P<0.05). The mean content of pH in raw chicken meat samples was 6.9±0.2 at the end of the maintenance period. Numerical noteworthyvariances were gotten for the mean content of pH amid raw chicken meat samples and *L. lactis* control group in 3th, 5th and 7th days of maintenance (P<0.05).

TABLE 1. List of primers used for study the nisin gene expression by the RT-PCR.

Target gene	Product	Primer sequence (5′–3′)	Reference
16S rRNA	16S ribosomal RNA	F: GCTCACCAAGGCGATGATACATA R: ACCAACGTTCTTCTCTACCAACA	17
Nisin A	Nisin Structural Gene	F: TTCGAAGAAAGATTCAGGTGC R: TTGATTTGGTTATTTGCTTACGTG	This study

TABLE 2. Counting of *L. lactis* and *Ses*E on chicken meat during the maintenance period in culture media.

Groups	Treatments	Counts (CFU/ml) in days of maintenance			
		0	3	5	7
1	*Ses*E control group	1.40×10^{5} Bb*	7.00×10^{8} Aa	1.00×10^{10} Bb	6.60×10^{11} Aa
2	*Ses*E exposure group	1.90×10^{5} Ab	3.50×10^{8} Ca	1.00×10^{10} Bb	1.00×10^{11} Bb
3	*L. lactis* control group	1.40×10^{8} Ba	1.20×10^{9} Da	1.60×10^{9} Aa	1.20×10^{10} Ba
4	*L. lactis* exposure group	1.30×10^{8} Bb	5.00×10^{8} Ba	1.20×10^{9} Bb	1.10×10^{10} Bb

*Unlike capital letters in each column illustrate numerical noteworthy variances about P <0.05.
Unlike small letters in each row illustrate numerical noteworthy variances about P <0.05.

TABLE 3. Counting of *L. lactis* and *Ses* E on chicken meat during the maintenance period in chicken meat.

Groups	Treatments	Counts (CFU/ml) in days of maintenance			
		0	3	5	7
1	*Ses*E control group	2.80×10^{5} Cc*	4.30×10^{7} Bb	1.10×10^{10} Aa	5.70×10^{11} Aa
2	*Ses*E exposure group	1.00×10^{5} Cc	5.00×10^{6}Cb	9.40×10^{6} Bb	3.00×10^{7} Ba
3	*L. lactis* control group	9.00×10^{7}Bd	9.60×10^{9} Ac	2.60×10^{10} Ab	6.00×10^{11} Aa
4	*L. lactis* exposure group	2.60×10^{8} Ac	1.00×10^{10}Ab	1.50×10^{10} Ab	1.70×10^{11} Aa

*Dissimilar capital letters in each column illustrate numerical noteworthy variances about P <0.05.
Dissimilar small letters in each row illustrate numerical noteworthy variances about P <0.05.

TABLE 4. pH changes of chicken meat samples inoculated with *L. lactis* during the maintenance period.

Treatments	pH in days of maintenance			
	0	3	5	7
L. lactis control group	5.8±0.2 Aa*	5.4±0.1 Ab	5.1±0.2 Ac	5.0±0.1 Ac
Raw meat samples	5.9±0.1 Ac	6.1±0.1 Bc	6.5±0.2 Bb	6.9±0.2 Ba

*Dissimilar capital letters in each column illustrate numerical noteworthy variances about P <0.05.
Dissimilar small letters in each row illustrate numerical noteworthy variances about P <0.05.

Table 5 characterizes the protein contents of chicken meat samples inoculated with *L. lactis* during the maintenance period according to Kjeldahl method. The mean content of protein in chicken meat samples in *L. lactis* control group was 17.90±1.25 at the beginning of the maintenance period. The mean content of protein of chicken meat samples in *L. lactis* control group has been decreased (P>0.05). The mean content of protein in chicken meat samples in *L. lactis* control group was 17.02±1.36 at the end of the maintenance period. The mean content of protein in raw chicken meat samples was 17.93±1.05 at the beginning of the maintenance period. The mean content of protein of raw chicken meat samples has been numerical decreased (P<0.05). The mean content of protein in raw chicken meat samples was 14.29±1.25 at the end of the maintenance period. Numerical noteworthy variances were gotten for the mean content of protein amid raw chicken meat samples and *L. lactis* control group in 3th, 5th and 7th days of maintenance (P<0.05).

Presence of the *nisin A* gene in the *L. lactis* bacteria was approved by means of conventional PCR reaction. Figure 1 characterizes the consequences of the PCR visualization of nisin A gene using the PCR method. We found that all strains had nisin A gene.

Accuracy of RNA extraction and quality of extracted RNA were assessed using the gel electrophoresis. Totally, presence of *16S*, *18S* and *28SrRNA* genes were analyzed in the gel electrophoresis.

Figure 2 characterizes the relative gene expression examination of nisin in *L. lactis* subsp. lactiscombination with *Se*s E in chicken meat samples 4 h after the beginning of maintenance period at 12 °C. Results exhibited that the amount of nisin gene expression in *L. lactis* subsp. lactis co-culture with *Se*s E (*L. lactis* exposure group) was 1.9 times higher than *L. lactis* subsp. lactis mono-culture (*L. lactis* control group). Numerical noteworthy variances were gotten for the nisin

TABLE 5. Protein changes of chicken meat samples inoculated with *L. lactis* during the maintenance period.

Treatments	Protein (%) in days of maintenance			
	0	3	5	7
L. lactis control group	17.90±1.25 Aa*	17.65±1.41 Aa	17.20±1.55 Aa	17.02±1.36 Aa
Raw meat samples	17.93±1.05 Aa	16.89±1.72 Bb	15.41±1.19 Bc	14.29±1.25 Bd

*Dissimilar capital letters in each column illustrate numerical noteworthy variances about P <0.05.

Dissimilar small letters in each row illustrate numerical noteworthy variances about P <0.05.

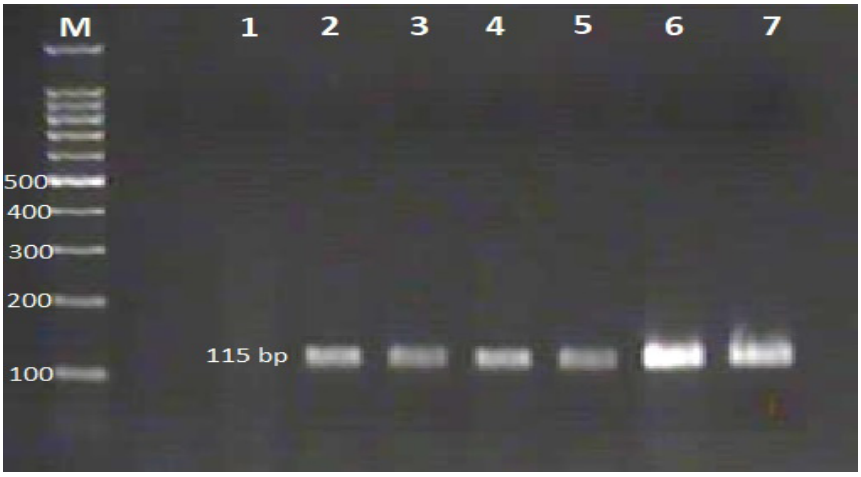

Fig. 1. Results of the gel electrophoresis of the nisin A gene in the *L. lactis* strains. M: 100 bp ladder (Thermo Fisher Scientific, St. Leon-Rot, Germany), lane 1: Negative control (PCR grade water (Thermo Fisher Scientific, St. Leon-Rot, Germany)), lanes 2-6: positive samples for the nisin A gene in the *L. lactis* (115 bp) and lane 7: Positive control (*L. lactis* ATCC 11454).

gene expression amid *L. lactis* exposure group and *L. lactis* control group (P =0.0008).

Figure 3 characterizes the relative gene expression examination of nisin in *L. lactis* subsp. lactis combination with *Se*sE in chicken meat samples after 48 h of maintenance at 12 °C. Results showed that the amount of nisin gene expression in *L. lactis* subsp. lactis mono-culture (*L. lactis* control group) was 1.1 times higher than *L. lactis* subsp. lactiscombination with *Se*sE (*L. lactis* exposure group). This finding exhibited decrease in the nisin gene expression in *L. lactis* subsp. lactiscombination with *Se*sE after 48 h of maintenance at 12 °C. Nevertheless, there were no numerical noteworthy variances for the nisin

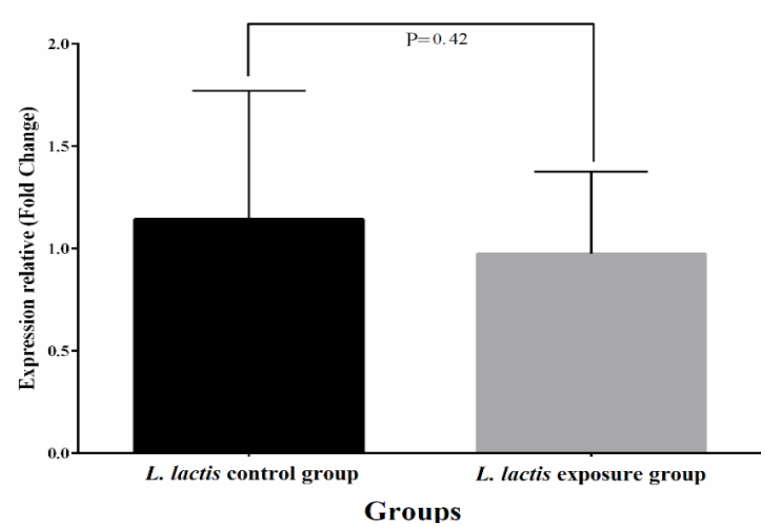

Fig. 2. Relative gene expression analysis of nisin in *L. lactis* subsp. lactis co-culture with *Se*sE in chicken meat samples 4 h after the beginning of maintenance period at 12 °C. Changes in gene expressions were measured using quantitative reverse transcription PCR (RT-qPCR).

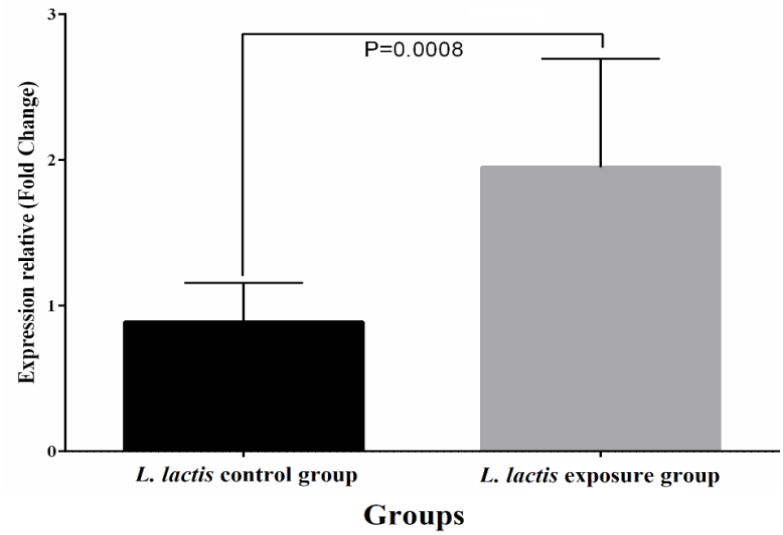

Fig. 3. Relative gene expression analysis of nisin in *L. lactis* subsp. lactis co-culture with *Se*sE in chicken meat samples after 48 h of maintenance at 12 °C. Changes in gene expressions were measured using quantitative reverse transcription PCR (RT-qPCR).

gene expression amid *L. lactis* exposure group and *L. lactis* control group (P =0.42).

Discussion

An existing survey was done to assess the role of *Se*sE on nisin gene expression induced by *L. lactis*on chicken meat samples. Apparently, this is an initial report of the study of effect of the *Se*sE on *L. lactis*nis in gene expression on chicken meat samples. Findings described that *L. lactis* caused significant decrease in the numbers of *Se*sE growth on chicken meat. Additionally, co-culture of *L. lactis* with *Se*sE caused significant increase in the nisin gene expression 4 h after the beginning of maintenance period of chicken meat samples at 12 °C which was interesting. Microbiological and food related investigations revealed that changes in the temperature, osmotic pressure and acidity are the greatest mutualtensioncircumstances originated in food stuffmanufacture and to which *L. lactis* nisin gene expressions subjected [20-22]. Additionally, inoculation and growth of certain bacteria in media and/or food systems in association with *L. lactis* is introduced as a probable factor increasing nisin gene expression [20-22].

Nisin mainly constrains growth of Gram-positive bacteria by pores formation in their membrane. Clearly, nisin is not operativetoward Gram-negative bacteria, since it cannot transfer through their cell membrane owing to its large molecular size [23]. However, our findings revealed that co-inoculation of nisin producer *L. lactis* with *Se*sE decrease the numbers of viable Salmonella in chicken meat samples. There were two probable reasons for this finding. At first, *L. lactis* caused significant decrease in the pH content of chicken meat samples which make the conditions hard for growth of *Se*sE. At second, increase in the expression of nisin gene caused by presence of *S Se*sE and subsequently higher production of nisin gene make the conditions hard for growth and survival of *Se*sE. Owing to presence of Gram-negative and nisin-resistant microorganisms, nisin may not be adequate to avoid meat spoilage. In keeping with this, decrease in the levels of pH and proteins (which may deliberate as significant stresses for nisin gene expression) and increase in the nisin gene expression induced by presence of Salmonella may be effective protocols caused significant increase in the levels of nisin. Thus, higher concentrations of nisin caused decrease in the numbers of *Se*sE.

We also found *L. lactis* inhibits from protein destructions in the chicken meat samples (in comparison with raw chicken meat samples). Therefore, using from *L. lactis* may inhibit from the reduction in nutritional qualities of chicken meat samples in the maintenance period. Additionally, decrease in the pH contents of chicken meat samples induced by *L. lactis* is the main factor inhibit from the growth of pathogenic bacteria and protein degradation. It has been conveyed that the flinch of the logarithmic development of *L. lactis* subsp. lactis was detectedamid 9 and 15 h at 12 °C. At these intervals, the uppermost decrease in pH of the chicken meat was also detected. The stationary phase at 12 °C started amid 18 and 24 h [19]. It has also been conveyed that nisin production was much higher in logarithmic phase of growth of *L. lactis* subsplactis [24]. Additionally, development of LAB in meat can lead to the little hydrolysis of its proteins (which was also seen in the present study) and formation of peptides with antimicrobial characteristics [25]. Additionally, intricate matrices, including meat and milk, mightdelay with the bactericidal dimensions of bacteriocins, owing tocommunications with lipids and proteins and proteolysis [26]. Therefore, it is not surprising that *L. lactis* caused sever decrease in the numbers of *Se*sE especially in its logarithmic phase of growth.

Amounts of gene expression in the *L. lactis* exposure group was higher than *L. lactis* control group 4 h after the beginning of maintenance period at 12 °C. Diversely, amounts of gene expression in the *L. lactis* control group was higher than *L. lactis* exposure group after 48 h of maintenance at 12 °C. The chiefmotive for this discovery is the fact that *L. lactis* had the highest nisin secretion at the logarithmic phase of growth. While, decrease in the growth of *L. lactis* (after 48 h) caused significant decrease in the nisin gene expression. The production of nisin is hang on density of cell and is monitored at the levels of manufacturing of peptides [27, 28]. In the motionlessstage of growth of *L. lactis* in combination, it wasn'ttalented to promptnisin gene over and above in modest cultures owing toinferior cell density of *L. lactis* in opposition with *Se*sE. Nevertheless, production of nisin in aninitial log stage of growth of *L. lactis* in combination was much developed than modest cultures. An existing divergencemight be associated with inferioraccessibility of supplementary constituents compulsory for

predecessor alteration of nisin, transportation and processing in mono-cultures. Numerous genes are donated for establishednisin production which are measured by supervisorys equences of DNA, positioned upstream of anencoding area. Effects of these genes after 12 h of inoculation of *L. lactis* in food samples have been decreased [27, 28]. Unfortunately, rare studies have been conducted about the effects of pathogenic bacteria on nisin gene expression of *L. lactis*. Abdollahi et al. (2018) [7] conveyed that the upper most quantities of nisin and its level of gene dictation were perceived in humble and combined cultures afterward 16 h of cultivation, simultaneous with the culmination of growth of *L. lactis*in described stage. They also showed that the *L. lactis* induced higher concentrations of nisin when it was in contact with pathogenic bacteria and especially *Se*s E and *Listeria monocytogenes* which were similar to our findings. Totally, role of food-borne pathogens in occurrence of food-borne diseases has been measured in Iran and diverse surveys have been conducted in this field [29-39].

Conclusion

In deduction, we identified a significant effects of *L. lactis* subsp. lactis on growth and proliferation of *Se*sE in chicken meat samples. Additionally, the effect of *Se*sE on nisin gene expression was observed. An existing survey is an initial report of assess the effect of *Se*sE on nisin gene expression induced by *L. lactis*on chicken meat samples. *L. lactis* caused significant decrease in the numbers of *Se*sE in chicken meat. Furthermore, *L. lactis* caused significant decrease in pH levels of chicken meat samples. It is also inhibits from protein destruction through the maintenance period. Amount of nisin gene expression after 4 h from the beginning of maintenance period at 12°C in *L. lactis* subsp. lactis co-culture with *Se*sE was 1.9 times higher than *L. lactis* subsp. lactis mono-culture. Reversely, amount of nisin gene expression after 48 h of maintenance at 12°C in *L. lactis* subsp. lactis mono-culture was 1.1 times higher than *L. lactis* subsp. lactis co-culture with *Se*s E. Therefore, presence of *Se*s Eis maybe the positive stress on nisin gene expression and subsequent production of nisin by *L. lactis* subsp. lactis especially 4 h after the beginning of maintenance period at 12 °C in chicken meat samples. The present investigation has some limitations such as failure to study the role of other pathogenic bacteria on nisin gene expression induced by *L. lactis* and lack of multifactorial survey on effects of different pH levels and temperature on nisin gene expression induced by *L. lactis*. However, the results of the present investigation may have some practical applications in food industry such as increase in production of natural nisin induced by *L. lactis* using the *Se*sE co-culture, decrease the load of *Se*sE in chicken meat using the nisin induced by addition of *L. lactis* and finally improve the sensory properties of chicken meat samples kept at 12 °C by nisin induced by *L. lactis*.

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Conflict of interest:

The authors declared that no conflict of interest.

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