Efficacy of Purified Bacteriocin of “Brevibacillus laterosporus TK3” against Listeria monocytogenes and Staphylococcus aureus in Chicken

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ABSTRACT

In the present investigation the biopreservative effect of bacteriocin of Brevibacillus laterosporus TK3 was investigated in raw chicken. Bacteriocin producing strain has been isolated from “Tatwakhar”, a flour prepared from seeds of Indian Horse Chestnut (Aesculus indica). Bacteriocin of Brevibacillus laterosporus TK3 showed strong antagonism against food spoilage/pathogenic bacteria viz. Listeria monocytogenes and Staphylococcus aureus. The bacteriocin was purified and molecular weight of this novel bacteriocin was found to be 6 kDa. This purified bacteriocin with specific activity 34,482.0 AU/mg was applied in raw chicken and minced chicken against L. monocytogenes and S. aureus which showed the positive results in controlling the growth of these deadly pathogens. Purified bacteriocin was found successful in controlling the growth of L. monocytogenes up to 7th day which is almost at par with the results achieved with chemical preservative i.e. sodium nitrite. Further, purified bacteriocin restricted the growth of S. aureus up to 5th day whereas chemical preservative was able to control the growth of S. aureus up to 3rd day. The results found in these experiments deal with application of bacteriocin as biopreservative in chicken as an alternative to chemical preservative are quite encouraging and satisfactory.

Key words: Bacteriocin, Biopreservative, Brevibacillus laterosporus, Chicken, L. monocytogenes, S. aureus.

INTRODUCTION

The microbiological spoilage of raw chicken is due to the biochemical activity of microorganisms causing changes in its appearance, odour, texture or taste. Several bacterial pathogens including Salmonella, Campylobacter jejuni, Escherichia coli, Listeria monocytogenes, Staphylococcus aureus and Clostridium botulinum are found associated with many food borne illnesses which are serious public health concern worldwide. So to maintain the quality and safety of foods various measures are generally adopted in food industry i.e. good manufacturing practices, good hygienic practices etc. but preservation of food by a suitable means is the key of food quality and safety. There are number of preservation techniques started from low temperature preservation like refrigeration, freezing etc. and thermal preservation techniques like pasteurization, sterilization and preservation using certain chemicals (Singh, 2018).

Generally, food industry depends on chemicals for the preservation of foodstuff and to increase the shelf life of food. Chemical preservatives and other conventional preservation strategies fail to deliver the requisite health benefits and cause serious disorder thus necessitates seeking alternatives (Sarika et al., 2019). Hence, according to an increased negative perception towards chemical preservatives and a trend towards natural food additives so called “clean- labeling” has driven exploring of effective natural antimicrobial compounds as an alternative to synthetic food additives (Castiliano et al., 2008). The use of bacteriocins is a promising ongoing development in food preservation as bacteriocins have strong antagonism against most of the food borne pathogens. In the food industry, bacteriocins have been widely utilized for the biopreservation of various foods, either alone, or in combination with other methods of preservation known as hurdle technology (Galvez et al., 2007; Barathiraja et al., 2015). Incorporation of bacteriocins into the food packaging film or surfaces has been explored as well (Zendo, 2013). Bacteriocins are ribosomally synthesized extracellularly released bioactive peptides or peptide complexes that vary in spectrum of activity, mode of action, molecular weight, genetic organization and considered to be safe biopreservatives since they can be digested by proteases thus having no or little influence on the gut microbiota.
(Padmaja et al., 2011). The lantibiotic nisin, which contains unusual amino acids such as lanthionine and β-methyllanthionine, is the most studied bacteriocin to date and is the only bacteriocin currently used as a food additive (Zheng et al., 1999), however, the use of nisin is limited due to its very low activity at neutral or alkaline pH. Therefore, the search for novel bacteriocins with improved biochemical properties, including stability over a wide pH range, thermostability and a broad antimicrobial spectrum, is of great interest for applications in foods. As different types of bacteria produce different kinds of bacteriocins, therefore, there is a pressing need to explore the nascent field of natural food biopreservation by isolating different bacteria from new sources capable of producing novel bacteriocins and to characterize them to be added to food. Therefore, in the present investigation an attempt has been made to use purified bacteriocin of *Brevibacillus laterosporous* TK3 to preserve raw chicken.

**MATERIALS AND METHODS**

The experiments were conducted at Department of Basic Sciences (Microbiology Section), Dr. Y. S. Parmar University of Horticulture and Forestry, Nauni, Solan, H.P. India in the year 2018-19. Bacteriocin producing *Brevibacillus laterosporous* TK3, isolated from “Tatwakhar”- a flour prepared from seeds of Indian Horse Chestnut (*Aesculus indica*). The bacteriocin was purified by single step gel exclusion chromatography. This thermostable bacteriocin with molecular weight 6 kDa, specific activity 34,482.0 AU/mg and with strong antagonistic potential against *L. monocytogenes* and *S. aureus* was applied as a biopreservative to enhance shelf life of chicken. Application of purified bacteriocin as a biopreservative was studied for fresh raw chicken. Two variants of raw chicken i.e. chicken cubes and minced chicken were used. Pathogenic bacteria viz. *L. monocytogenes* and *S. aureus* were used as test inoculums to study the comparative effect of purified bacteriocin and chemical preservatives i.e. sodium nitrite in the food samples. Controls without any preservative were run in parallel.

**Preservation study in fresh raw chicken cubes**

Fresh raw chicken (1 kg) was procured from local market. Chicken cubes of size 1 x 1 x 1 cm using sterile measuring scale were cut by sterilized surgical blade. These were surface sterilized by instant dipping in 60% ethanol and were further dried in aseptic conditions for two hours under laminar flow to evaporate excess residual ethanol. A treatment of 20 chicken cubes each was used for every treatment. These chicken cubes were given uniform dipping in purified bacteriocin (2000 AU/ml), test indicators viz. *L. monocytogenes* and *S. aureus* (10^6 CFU/ml) and sodium nitrite (200 mg/l) in a sterilized beaker for two min. In total 18 Treatments were prepared as given below:

- **Treatment A_1**: Control (chicken cubes without any treatment)
- **Treatment A_2**: Control (Minced chicken without any treatment)
- **Treatment B_1**: Chicken cubes + *S. aureus*
- **Treatment B_2**: Minced chicken + *S. aureus*
- **Treatment C_1**: Chicken cubes + *L. monocytogenes*
- **Treatment C_2**: Minced chicken + *L. monocytogenes*
- **Treatment D_1**: Chicken cubes + purified bacteriocin + *S. aureus*
- **Treatment D_2**: Minced chicken + purified bacteriocin + *S. aureus*
- **Treatment E_1**: Chicken cubes + purified bacteriocin + *L. monocytogenes*
- **Treatment E_2**: Minced Chicken + purified bacteriocin + *L. monocytogenes*
- **Treatment F_1**: Chicken cubes + purified bacteriocin + *L. monocytogenes*
- **Treatment F_2**: Minced Chicken + purified bacteriocin + *L. monocytogenes*
- **Treatment G_1**: Chicken cubes + chemical preservative (NaNO_2)
- **Treatment G_2**: Minced Chicken + chemical preservative (NaNO_2)
- **Treatment H_1**: Chicken cubes + NaNO_2 + *S. aureus*
- **Treatment H_2**: Minced Chicken + NaNO_2 + *S. aureus*
- **Treatment I_1**: Chicken cubes + NaNO_2 + *L. monocytogenes*
- **Treatment I_2**: Minced chicken + NaNO_2 + *L. monocytogenes*

These samples were stored in sterilized zip-lock bags and were kept at 20°C±2 for 30 days for storage studies.

**Preservation study of fresh raw minced chicken**

Minced chicken was prepared by grinding 1.0 kg boneless chicken in mixer- grinder. It was surface sterilized by instant dipping in 60% ethanol and was further dried in aseptic conditions for two hours under laminar flow to evaporate excess residual ethanol. 20 gm of minced chicken was used for every treatment. Uniform dipping was given in purified bacteriocin (2000 AU/ml), test indicators viz. *L. monocytogenes* and *S. aureus* (10^6 CFU/ml) and sodium nitrite (200 mg/l) in a sterilized beaker for two min. Treatments were prepared as described previously.

**Microbiological evaluation of fresh raw chicken cubes and minced chicken**

Microbiological evaluation of the samples was done periodically on 0, 3, 5, 7, 10, 15, 21 and 30 days. CFU/ml for each sample was calculated on nutrient agar and the total count was evaluated in terms of log CFU/ml (Gautam and Sharma, 2014).

**RESULTS AND DISCUSSION**

Thermostable bacteriocin of *Brevibacillus laterosporous* TK3-NCBI accession no KP861913.1 is used in preservation of chicken. The consumption of poultry products has been steadily increasing worldwide, not only because of their relatively low cost but for the high nutritional value that it contains. Poultry meat support the growth of pathogens e.g. *L. monocytogenes, S. aureus* and *Salmonella*, are the most commonly reported pathogens implicated in food borne outbreaks (Jofre et al., 2008). *L. monocytogenes* is known as the causative agent of listeriosis, a disease chiefly...
dangerous to certain risk groups, such as immune-compromised patients, pregnant women, new born, the elderly and (Shamloo et al. 2019). Staphylococcal food poisoning is a gastrointestinal illness caused by food contaminated with toxins produced by S. aureus (Landgraf and Destro, 2013). Hence, chicken was used in the present study to compare the preservative effect of purified bacteriocin and chemical preservative against pathogens associated with chicken.

Comparison of preservative potential of bacteriocin with chemical preservative in raw chicken cubes against L. monocytogenes

The biopreservative effect of purified bacteriocin of Brevibacillus laterosporus TK3 against L. monocytogenes in chicken cubes is represented in Table 1. Surface sterilized chicken cubes were taken to determine the effect of biopreservation during storage at room temperature and compared with chemical preservative i.e. sodium nitrite. Bacteriocin and chemical preservative were applied in chicken cube within permissible limit. Results of preservation studies performed with chicken cubes were quite interesting when performed on 0, 3rd, 5th, 7th, 10th, 15th, 21st and 30th days. The total bacterial count (TBC) in control (Treatment A) started developing from 3rd day almost at par with chemical preservative. Bacteriocin and chemical preservative were able to prevent the growth of bacteria up to 5th day and meager growth was observed from 7th day onwards. On 21st day and 30th day slight increase in the bacterial growth was observed (Table 1). In case of chicken cubes inoculated with L. monocytogenes (Treatment C), growth started developing from 3rd day onwards with rapid rise in growth of L. monocytogenes on 5th, 7th and 10th day. On 15th day and afterwards growth became countless. In chicken cubes with purified bacteriocin plus L. monocytogenes (Treatment E) and chicken cubes inoculated with chemical preservative plus L. monocytogenes (Treatment I), purified bacteriocin as well as chemical preservative were able to contain the growth of L. monocytogenes notably up to 7th day of storage. Growth of L. monocytogenes started developing from 10th day onwards with log CFU 7.99 in chicken cubes with bacteriocin and log 7.76 in chicken cubes with chemical preservative with considerable rise in counts on day 15th, 21st and on 30th day respectively. From the results of this experiment it was observed that the purified bacteriocin of Brevibacillus laterosporus TK3 was effective in controlling the total bacterial count in chicken cubes up to 7th day of storage with very slow increase in bacterial count up to 30th day of storage almost at par with chemical preservative as compared to control in which bacterial count appeared on 3rd day and reached to infinity from fifteenth day onwards. Similarly, the purified bacteriocin was successful in controlling the growth of food borne pathogen L. monocytogenes up to 7th day as compared to control inoculated with L. monocytogenes which is almost at par with the results achieved with chemical preservative. An analogous study by (Sarika et al., 2012) has been demonstrated in literature. They reported that bacteriocin PSY2 could provide a promising alternative to harmful chemical preservatives in stored fish as it was effective against L. monocytogenes when compared with chemical preservative.

Comparison of preservative potential of bacteriocin with chemical preservative in raw chicken cubes against S. aureus

Fig1 represents the comparative biopreservative effect of purified bacteriocin of Brevibacillus laterosporus TK3 against S. aureus in chicken cubes during 30 days of storage at room temperature. Control (Treatment A) started developing total bacterial count i.e. 6.30 log CFU/ml on the third day which rose to log 7.41 CFU on fifth day, log 8.01 on seventh day, 8.14 on tenth day, 8.30 on fifteenth day, 8.48 on 21st day and became countless afterwards. Chicken cubes inoculated with purified bacteriocin (Treatment F) and with chemical preservative (Treatment G) were found able to prevent the growth of bacteria up to 5th day and meager growth of food spoilage L. monocytogenes was observed from 7th day onwards i.e. log 6.48 and 6.30, log 7.20 and log 7.08 on day 10th, log 7.46 and log 7.36 on fifteenth day, log 7.66 and log 7.59 on 21st day and again with slight increase on 30th day with log 7.71 and log 7.67 respectively. In case of chicken cubes inoculated with S aureus (Treatment B), heavy growth of S. aureus developed from 3rd day onwards with log 8.40 CFU/ml with rapid rise reaching to log 8.48 on day five and uncountable afterwards. Chicken cubes inoculated with purified bacteriocin plus S. aureus (Treatment D) and chicken cubes with chemical preservative plus inoculated with S. aureus (Treatment H), bacteriocin as well as chemical preservative were able to contain the growth of S. aureus up to 5th day of storage. Growth of S. aureus started developing from 7th day onwards with log 7.88 in chicken cubes with bacteriocin and log 7.80 in chicken cubes with chemical preservative with considerable rise in counts on 10th day i.e. log 8.11 and log 8.10 log 8.26 and log 8.22 on 15th day, log 8.42 and log 8.40 and log 8.48 and log 8.46 on 30th day respectively. From the results of this experiment it was observed that the purified bacteriocin was successful in prevent the growth of food spoilage S. aureus up to 7th day almost at par with results achieved with chemical preservative as compared to control inoculated with S. aureus in which heavy growth of S. aureus appeared on 3rd day only and reached to uncountable preposition from fifth day onwards.

Comparison of preservative potential of bacteriocin with chemical preservative in minced chicken L. monocytogenes

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Table 1: Comparison of preservative potential of bacteriocin with chemical preservative in raw chicken cubes against *L. monocytogenes.*

| Treatments /Days | 0 (log CFU/ml) | 3 (log CFU/ml) | 5 (log CFU/ml) | 7 (log CFU/ml) | 10 (log CFU/ml) | 15 (log CFU/ml) | 21 (log CFU/ml) | 30 (log CFU/ml) |
|------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Control          | A<sub>i</sub> | -              | 6.30           | 7.41           | 8.01           | 8.14           | 8.30           | 8.48           |
| CC<sup>*</sup> + *L. monocytogenes* | C<sub>i</sub> | -              | 6.48           | 7.77           | 8.22           | 8.32           | 8.48           | 8.48           |
| CC + Bacp** + *L. monocytogenes* | E<sub>i</sub> | -              | -              | -              | 7.99           | 8.25           | 8.39           | 8.47           |
| CC<sup>*</sup> + NaNO<sub>2</sub> + *L. monocytogenes* | I<sub>i</sub> | -              | -              | -              | 7.76           | 8.08           | 8.30           | 8.40           |
| CC<sup>*</sup> + Bacp** | F<sub>i</sub> | -              | -              | -              | 6.48           | 7.20           | 7.46           | 7.66           |
| CC<sup>*</sup> + NaNO<sub>2</sub> | G<sub>i</sub> | -              | -              | -              | 6.30           | 7.08           | 7.36           | 7.59           | 7.67           |

*CC*: Chicken cubes

*Bacp**: Purified bacteriocin

*UC*: Uncountable

*laterosporus TK3* against *L. monocytogenes* in minced chicken is shown in the Table 2. Biopreservation was compared with commercial chemical preservatives i.e. sodium nitrate to evaluate its effect in minced chicken. Preservatives, bacteriocin and chemical preservative were applied in minced chicken within permissible limits. Results of preservation studies performed with minced chicken were quite encouraging when performed on 0, 3<sup>rd</sup>, 5<sup>th</sup>, 7<sup>th</sup>, 10<sup>th</sup>, 15<sup>th</sup>, 21<sup>st</sup> and 30<sup>th</sup> days. The total bacterial count (TBC) in control (Treatment A<sub>j</sub>) were recorded 7.95 log CFU/ml on the third day which rose to log 8.20 CFU on fifth day, log 8.37 on seventh day, 8.43 on tenth day, 8.48 on fifteenth day and became countless afterwards. Minced chicken inoculated with purified bacteriocin (Treatment F<sub>j</sub>) and minced chicken with chemical preservative (Treatment G<sub>j</sub>) were found able to prevent the growth of bacteria up to 3<sup>rd</sup> day and meager growth was observed from 5<sup>th</sup> day to 21<sup>st</sup> day and again with slight increase on 30<sup>th</sup> day was observed. In case of minced chicken inoculated with *L. monocytogenes* (Treatment C<sub>j</sub>), growth started developing from 3<sup>rd</sup> day onwards with rapid rise in growth of *L. monocytogenes* (Treatment E<sub>j</sub>) and minced chicken with chemical preservative plus inoculated with *L. monocytogenes* (Treatment I<sub>j</sub>), purified bacteriocin as well as chemical preservative were able to contain the growth of *L. monocytogenes* not only up to 5<sup>th</sup> day of storage. Growth of *L. monocytogenes* started developing from 7<sup>th</sup> day onwards with log 7.89 in minced chicken with bacteriocin and log 7.84 in minced chicken with chemical preservative with considerable rise in counts on day ten i.e. log 8.00 and log 7.88 on 15<sup>th</sup> day, log 8.32 and log 8.28 on 21<sup>st</sup> day, log 8.47 and log 8.40 on 30<sup>th</sup> day respectively.

From the results of this experiment it was observed that the purified bacteriocin of *Brevibacillus laterosporus TK3* was effective in controlling the total bacterial count in minced chicken up to 3<sup>rd</sup> day of storage with slow increase in bacterial count up to 30<sup>th</sup> day of storage, which was even better than the chemical preservative when compared to control in which bacterial count appeared on 3<sup>rd</sup> day and reached to infinity from fifteenth day onwards. Similarly, the...
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Table 2: Comparison of preservative potential of bacteriocin with chemical preservative in minced chicken cubes against L. monocytogenes.

| Treatments                        | 0 (log CFU/ml) | 3 (log CFU/ml) | 5 (log CFU/ml) | 7 (log CFU/ml) | 10 (log CFU/ml) | 15 (log CFU/ml) | 21 (log CFU/ml) | 30 (log CFU/ml) |
|-----------------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Control                           | A2             | 7.95           | 8.20           | 8.37           | 8.43           | 8.48           | UC             | UC             |
| MC + L. monocytogenes             | C2             | 8.05           | 8.29           | 8.40           | 8.48           | UC             | UC             | UC             |
| MC + Bacp + L. monocytogenes      | E2             | -              | -              | 7.89           | 8.00           | 8.14           | 8.32           | 8.47           |
| MC + NaNO2 + L. monocytogenes     | I2             | -              | -              | 7.84           | 7.88           | 8.09           | 8.28           | 8.40           |
| MC + Bacp                         | F2             | -              | -              | 6.95           | 7.20           | 7.45           | 7.56           | 7.64           |
| MC + NaNO2                        | G2             | -              | -              | 7.04           | 7.32           | 7.51           | 7.63           | 7.69           |

MC* Minced chicken
Bacp** Purified bacteriocin
UC: Uncountable

purified bacteriocin was successful in containing the growth of L. monocytogenes up to 7th day as compared to control inoculated with L. monocytogenes which is even better than with the results achieved with chemical preservative. These findings are in agreement with the few results currently available in the literature, including the work of (Chakchouk-Mtibaa et al., 2017), where the effect of the semi purified bacteriocin BacFL31 was investigated on the shelf life of refrigerated raw ground turkey meat. The findings indicated that BacFL31 treatments were effective against Listeria monocytogenes and Salmonella Typhimurium.

Comparison of preservative potential of bacteriocin with chemical preservative in minced chicken against S. aureus

Fig 2 represents the comparative biopreservative effect of purified bacteriocin of Brevibacillus laterosporus TK3 against S aureus in minced chicken during 30 days of storage at room temperature. On the initial 0 day log CFU/ml for minced chicken were not detected. The total bacterial count (TBC) in control (Treatment A2) were recorded 7.95 log CFU/ml on the third day which rose to log 8.20 CFU on fifth day, log 8.37 on seventh day, 8.43 on tenth day, 8.48 on fifteenth day and became countless afterwards. In case of minced chicken inoculated with S aureus (Treatment B2), heavy growth of S. aureus developed and reached to uncountable level on 3rd day only with log 8.48 CFU/ml. In minced chicken with purified bacteriocin inoculated with S. aureus (treatment D2) purified bacteriocin was able to contain the growth of S. aureus up to 5th day whereas in case minced chicken with chemical preservative and inoculated with S. aureus (Treatment H2), growth of log 6.85 of S. aureus appeared on 5th day itself. On 7th day log 7.98 of S. aureus was observed in minced chicken with bacteriocin and log 7.99 was noted in minced chicken with chemical preservative which rose to log 8.12 and log 8.14 on 10th day, log 8.21 and log 8.25 on 15th day, log 8.45 and log 8.46 on 30th day, respectively.

From the results of this experiment it was observed that the purified bacteriocin was successful in containing the growth of S. aureus up to 5th day whereas chemical preservative was able to contain the growth of S. aureus up to 3rd day only as compared to control inoculated with S. aureus. The results found in these experiments for application of bacteriocin as biopreservative in chicken as an alternative to chemical preservative are quite encouraging and
satisfactory. However, these findings could be refined and used meticulously after combining the use of bacteriocin along with other novel approaches like, anti-microbial film packaging, hurdle technologies etc. But, definitely this study has indicated the strong possibility of success of using bacteriocins for enhancing the shelf life of meat products. According to one such report the application of bacteriocin plantaricin IIA-1A5 of *Lactobacillus plantarum* IIA-1A5 was compared with 0.3% nitrite to extended the shelf life of beef meatball. Interestingly, 0.3% plantaricin IIA-1A5 displayed the ability to inhibit a population of *S. aureus* as strong as 0.3% nitrite during the storage period demonstrating promising potential use of plantaricin as a nitrite replacer. (Sarika *et al.*, 2015).

**CONCLUSION**

In the present investigation efforts were made to use purified bacteriocin of *Brevibacillus laterosporus TK3* as biopreservative to enhance the shelf life of chicken products. Purified bacteriocin was found almost as effective as chemical preservative in comparative studies. Encouraging results of the study suggests that the bacteriocin of *Brevibacillus laterosporus TK3* has a strong potential as an alternative to replace synthetic food additives- sodium nitrite for safer preservation of food products in food industry.

**REFERENCES**

Barathiraja, S., Thanisllass, J., Antony, P.X., Venkatesaperumal S. (2015). Antimicrobial activity of bacteriocin isolated and purified from rumen liquor collected from slaughtered goats. Indian Journal of Animal Research. 49: 802-807.

Castillano, P., Belfiore, C., Fadda, S., Vignolo (2008). A review of bacteriocinogenic lactic acid bacteria used as starter cultures in fresh meat produced in Argentina. Meat Science. 79: 483-499.

Chakchouk-mtibaa, A., Smaoui, S., Ktari, N., Seillem, I., Najah, S., Karray-rebai, I., Melloul, L. (2017). Biopreservative efficacy of bacteriocin BacFL31 in raw ground turkey meat in terms of microbiological, physicochemical and sensory qualities. Biocontrol Science. 22 (2): 67–77.

Galvez, A., Abriouel, H., Lopez, R.L., Ben, O.N. (2007). Bacteriocin-based strategies for food biopreservation. International Journal of Food and Microbiology. 120(1-2): 51-70.

Gautam, N., Sharma, N. (2014). Quality attributes of a novel cereal based probiotic product prepared by using food grade lactic acid bacteria. Indian Journal of Traditional Knowledge. 13(3): 525-530.

Jofre, A., Garriga, M., Aymerich, T. (2008). Inhibition of *Salmonella* sp., *Listeria monocytogenes* and *Staphylococcus aureus* in cooked ham by combining antimicrobials, high hydrostatic pressure and refrigeration. Meat Science. 78: 53-59.

Landgraf, M., Destro, M.T. (2013). Staphylococcal food poisoning, food born infections intoxications. In: Food Science and Technology. (eds. J.G. Morris and M.E. Potter). Academic, Boston. pp. 389-400.

Padmaja, G.A., Ramchandra, B., Manjunath, H., Prabha, R., Krishna, R., Shankar, P.A. (2011). Characterization of lactic acid bacteria isolated from fruits and vegetables for their antibacterial activity. Asian Journal of Dairy and Food Research. 30(2):85-89.

Sarika, A.R., Lipton A.P., Aishwrya, M.S. (2019). Biopreservative efficacy of Bacteriocin GP1 of *Lactobacillus rhamnosus* GP1 on Stored Fish Filet. Front. 6: 29.

Sarika, A.R., Lipton, A.P., Aishwarya, M.S. (2015). Bacteriocin production by a new isolate of *Lactobacillus rhamnosus* GP1 under different culture conditions. Advance Journal of Food Science and Technology. 2(5): 291-297.

Shamloo, E., Hosseini, H., Abdi, M.Z, Halberg L.M., Haslberge, A., Alebouyeh M. (2019). Importance of *Listeria monocytogenes* in food safety: a review of its prevalence, detection and antibiotic resistance. Iran J Vet Res. 20(4): 241 254.

Singh, V.P. (2018). Recent approaches in food biopreservasion. Open Veterinary Journal. 8(1): 104 -111.

Zendo, T. (2013) Screening and characterization of novel bacteriocins from lactic acid bacteria. Bioscience, Biotechnology and Biochemistry. 77: 893-899.

Zheng, G., Yan, L.Z., Vederas, J.C., Zuber, P. (1999). Genes of the sbo-alb locus of Bacillus subtilis are required for production of the antilisterial bacteriocin subtilosin. Journal of Bacteriology. 181: 7346-7355.