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Research Paper

Effect of Nisin on the Quality Characteristics of Fiber-Enriched Chicken Harrisa

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ABSTRACT

Fiber-enriched chicken Harrisa was developed by incorporating optimum level of different fiber sources viz. oat bran (10%), wheat bran (10%) and barley bran (5%) separately. The products developed were further treated with nisin (500 I.U/g) and were aerobically packaged in low density polyethylene pouches along with control and assessed for oxidative stability and storage quality under refrigerated (4±1^{o}C) conditions. The products were evaluated for various physicochemical, microbiological and sensory parameters at regular intervals of 0, 7, 14 and 21 days. The products incorporated with nisin showed significantly ($p<0.05$) lower values for total plate count and psychrophilic count throughout the period of storage. Coliforms were not detected throughout the period of storage. Significantly ($p<0.05$) higher scores were observed for various sensory parameters of the products incorporated with nisin. Nisin successfully improved the storage quality of the fiber-enriched chicken Harrisa during refrigerated (4±1^{o}C) storage and may be commercially exploited to improve the storage quality of the product.

Keywords : *Nisin, Harrisa, Chicken, Fiber, Storage quality*

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INTRODUCTION

Harrisa is a traditional and convenient ready-to-eat meat product of the state of Jammu and Kashmir which is very much relished by the people particularly in winter months. The product is usually prepared from beef, mutton or chevon but can also be prepared from chicken or fish. The product is energy dense and lacks dietary fiber and as such it is unacceptable to a health conscious society and requires immediate scientific attention with respect to the fiber enrichment and quality improvement. Fiber is suitable for addition to meat products and has previously been used in meat products to increase the cooking yield due to its water-binding and fat-binding properties and to improve texture (Cofrades *et al*. 2000). The presence of fiber in foods produces a diminution in their caloric content. Several studies have proven that dietary fibers have the potential to reduce the blood low density lipoprotein (LDL) cholesterol, risk of diabetes mellitus type 2, coronary heart disease, blood pressure, obesity and colorectal cancer. However, the unwillingness of the consumer to change dietary habits suggests that there is a great market potential for foods with unchanged sensory attributes (Becker and Kyle 1998). Thus, there is need for the technology development of traditional meat products on commercial scales with improved nutritional characteristics but unchanged sensory attributes.

Research results indicate that possible food borne illnesses and quality problems are major concerns with traditional meat products and the changes such as antimicrobial and antioxidant incorporation and process modifications are the ways to improve safety and quality of these products (Kilic 2009). Among the various preservatives used, bacteriocins particularly nisin, are quite popular in the food industry. Bacteriocins are antimicrobial peptides, which are produced by bacteria to inhibit the growth of other closelyrelated organisms and can be potentially used as natural preservative (Boualem *et al.* 2013). Nisin is a polycyclic antibacterial 3.5 kDa cationic peptide produced commercially by culturing *Lactococcus lactis* on natural substrates such as milk or dextrose (O'Sullivan *et al.* 2002). It is degraded by gut enzymes and is stable under refrigerated conditions and shows heat stability. It extends the shelf life of the products by suppressing growth of bacteria. The spectrum of activity of nisin not only includes Gram-positive pathogens such as *Clostridium botulinum, Staphylococcus aureus, Listeria monocytogenes or Bacillus cereus*, but also meat spoilage organisms such as *Brochothrix thermosphacta, Lactobacillus spp.*(Najjar *et al.* 2007). Nisin antibacterial activity targets the cytoplasmic membrane where it inhibits peptidoglycan synthesis and supports the formation of pores (Boualem *et al.* 2013). Nisin is a permitted food additive in more than 50 countries, including the US and Europe,

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where it is used notably in processed cheeses, dairy products and canned foods (Boualem *et al*. 2013). Keeping in view all the above facts, the present study was envisaged to attempt the still inconclusive studies on utilization of nisin as a preservative in fiber-enriched chicken *Harrisa*.

MATERIALS AND METHODS

Chicken meat: Lean meat from commercially available broiler birds (6 weeks) was used. The body fat was trimmed off and deboning of dressed chicken was done manually by removing all the tendons and separable connective tissue. The lean meat was packed in polythene bags and stored under frozen conditions at -18 ± 2^{0}C until use.

Spice mixture: The spice mix formula used for preparation of the chicken *Harrisa* was standardized in the laboratory using aniseed (*Pimpinalla anisum*) 45%, coriander (*Coriandrum sativum*) 20%, cinnamon (*Cinnamomum zeylanicum*) 10%, black cardamom (*Amomum subulatum*) 8%, green cardamom *Elettaria cardamomum*) 7%, red chilli (*Capsicum frustescence*) 5%, black pepper (*Piper nigrum*) 2%, cloves (*Syzygium aromaticum*) 2% and coloured chilli (*Capsicum annum*) 1%. The spices were purchased from local market and were dried after removal of extraneous matter in an oven (50±2^{o}C) for overnight and then ground in grinder to powder. The coarse particles were removed using a sieve and the fine powdered spices were mixed in required proportion to obtain spice mixture. The spice mixture was stored in plastic airtight container for subsequent use.

Condiment mixture: To prepare the condiment mixture, the external coverings of onion and garlic were peeled off and cut into pieces. The cut pieces were weighed in a ratio of 3:1 and ground in a grinder to the consistency of fine paste.

Table 1: Formulation for preparation of chicken *Harrisa* per kilogram of meat.

Ingredients	Weight (g)
Meat	1000 g
Rice	150 g
Refined soyabean oil	100 g
Condiments	80 g
Spice mix	40 g
Salt	30 g
Water	3000 g

***Fiber sources and nisin*:** Three cereal fibre sources were used in the study viz. oat bran, barley bran and wheat bran. Preliminary trials were conducted to optimize the level of oat bran, wheat bran and barley bran. Commercially available brands were obtained from local market and were incorporated at different levels viz. 5%, 10% and 15% replacing rice in the formulation. Among the different levels, 10% level of oat bran or 10% level of wheat bran or 5% level of barley bran were optimized as best on the basis of sensory parameters and were chosen for further storage studies.Nisin was obtained from Himedia and used. Fiber-enriched chicken *Harrisa* was prepared and cooled. Nisin (500 I.U/g) was added and thoroughly mixed and packaged in low density polythene pouches.

Method of preparation of chicken Harrisa: Different trials were conducted to optimize the basic formulation (Table 1) and processing conditions for the preparation of chicken *Harrisa*. Different levels of rice (10%, 15% and 20%), refined oil (5%, 10% and 15%) and cooking temperature (90 ± 5°C, 100 ± 5°C) were tried. On the basis of various sensory parameters, 15% rice, 10% refined oil and 90 ± 5°C were optimized as best. For 1 kg of meat, 3 kg of water along with other ingredients viz. salt, condiments, rice, refined oil and spice mix were cooked in a pressure cooker (121^{o}C at 15 lbs) for 35±5 minutes. There after the mixture was again cooked in a deep oil fryer at 90 ± 5°C with constant stirring for a time till a product with thick consistency was obtained. The product so developed was treated with nisin and aerobically packaged in low density polyethylene (LDPE) pouches and was analyzed at a regular interval of 0, 7, 14 and 21 days during refrigerated storage at 4±1°C for various physicochemical, microbiological and sensory parameters.

Analytical procedures

pH and cooking yield: The pH of the product was determined by the method of Keller *et al.* (1974).

The cooking yield was expressed as percentage by the formula:

$$\text{Cooking yield Percent} = \frac{\text{Weight of cooked product}}{\text{Weight of raw product}} \times 100$$

Thiobarbituric acid reacting substances value (TBARS): Thiobarbituric acid reactive substances (mg malonaldehyde/kg) value was determined as per the method described by Witte *et al.* (1970).

Microbiological profile: Total plate count, psychrophillic count, coliform count and yeast and mold count were determined as per methods of APHA (1984).

Sensory evaluation: The sensory evaluation of fresh and stored samples was carried for various attributes namely appearance and colour, flavour, saltiness, texture and body, and overall acceptability by a panel of trained members composed of scientists and research scholars of the division based on a 8-point hedonic scale, wherein 8 denoted "extremely desirable" and 1 denoted "extremely undesirable" (Keeton 1983). The panellists were trained according to the guidelines of American Meat Science Association (1995) and were trained on product descriptions and terminology. Seven members of the panel replicated the experiment thrice (n=21). Panellists were seated in a room free of noise and odours and suitably illuminated. Coded samples for sensory evaluation were prepared and served warm to panellists at 40°C. Water was provided for oral rinsing between the samples.

Statistical analysis: Data obtained in the study was analysed statistically on 'SPSS-16.0' software package as per standard methods (Snedecor and Cochran 1994). Duplicate samples were drawn for each parameter and the experiment was replicated three times (n=6). Means for various parameters were analyzed using two-way ANOVA. Duncan's multiple range tests and critical difference were determined at the 5% significance level for comparing the means to find the difference between treatments and storage period. The values were presented as Mean±SE.

RESULTS AND DISCUSSION

The mean values of various physicochemical parameters of the fiber-enriched chicken *Harrisa* treated with nisin are presented in Table-2.

Table-2: Effect of nisin on the physicochemical parameters of aerobically packaged fiber-enriched chicken *Harrisa* under refrigerated (4±1°C) storage (Mean ± SE)*

Treatment	Storage period (Days)			
	0	7	14	21
		pH		
Control	6.17 ± 0.04^{a}	6.33 ± 0.01^{b}	6.50 ± 0.01^{c}	6.59 ± 0.01^{d}
(Oat Bran)	6.19 ± 0.02^{a}	6.32 ± 0.04^{b}	6.48 ± 0.02^{c}	6.61 ± 0.01^{d}
(Wheat Bran)	6.24 ± 0.03^{a}	6.37 ± 0.02^{b}	6.52 ± 0.01^{c}	6.63 ± 0.01^{d}
(Barley Bran)	6.21 ± 0.02^{a}	6.36 ± 0.02^{b}	6.49 ± 0.04^{c}	6.65 ± 0.03^{d}
		TBARS value (mg malonaldehyde/kg)		
Control	0.34 ± 0.01^{a}	0.46 ± 0.01^{b}	0.75 ± 0.02^{c}	1.16 ± 0.01^{d}
(Oat Bran)	0.29 ± 0.05^{a}	0.42 ± 0.02^{b}	0.68 ± 0.05^{c}	1.12 ± 0.03^{d}
(Wheat Bran)	0.31 ± 0.02^{a}	0.44 ± 0.01^{b}	0.72 ± 0.03^{c}	1.09 ± 0.04^{d}
(Barley Bran)	0.30 ± 0.04^{a}	0.45 ± 0.01^{b}	0.65 ± 0.06^{c}	1.10 ± 0.06^{d}
		Moisture (%)		
Control	71.46 ± 0.16^{d}	70.55 ± 0.32^{c}	69.68 ± 0.18^{b}	68.81 ± 0.24^{a}
T_1 (Oat Bran)	71.70 ± 0.16^{d}	70.41 ± 0.19^{c}	69.74 ± 0.17^{b}	69.17 ± 0.17^{a}
T_2 (Wheat Bran)	71.69 ± 0.25^{d}	70.75 ± 0.28^{c}	69.87 ± 0.14^{b}	69.05 ± 0.26^{a}
T_3 (Barley Bran)	70.60 ± 0.13^{d}	70.02 ± 0.07^{c}	69.45 ± 0.13^{b}	68.55 ± 0.21^{a}

*Mean ± SE with different superscripts in a row wise (lower case alphabet) and column wise (Upper case alphabet) differ significantly (p<0.05), n= 6 for each treatment. C = control without nisin, T_1 = chicken *Harrisa* with oat bran and nisin, T_2 = chicken *Harrisa* with wheat bran and nisin, T_3 = chicken *Harrisa* with barley bran and nisin

Physicochemical parameters

pH: A significant (p<0.05) effect of storage was observed on the pH values of control as well as treated products. All the products showed a significant (p<0.05) increasing trend with the period of storage and no significant (p>0.05) difference was observed between control and products treated with nisin. The increase in pH on subsequent days of storage might be attributed to formation of volatile basic nitrogen components as affected by biochemical changes under low temperature (Ibrahim and Desouky 2009) and also due to microbial load which may cause protein hydrolysis with the appearance of alkyl groups (Yassin 2003). In consonance to our results, Koplay and Sezer (2013) recorded no notable difference in pH between control and nisin treated groups during the storage period. Behnam *et al.* (2015) also reported non-significant (p>0.05) difference in pH between nisin treated and control groups of rainbow trout stored at refrigeration temperature.

Thiobarbituric acid reacting substances (TBARS) value: TBARS values of all the products followed an increasing trend throughout the period of storage and no significant (p>0.05) difference was observed between control and products treated with nisin. The values were well below the acceptable limit of 1 mg malonaldehyde per kilogram (Witte *et al.* 1970) for all the products up to 14th day of storage and exceeded the limit on 21st day of storage. Increased TBARS values for all products with the advancement of storage time could be attributed to lipid hydrolysis, oxidative rancidity and secondary products formation at refrigeration temperature (Forrest *et al.* 1975). The lower TBARS values of nisin treated products in comparison to control might be attributed to metal ion chelating or scavenging of reactive oxygen species by nisin (Lin and Yen 1999). Similar results were obtained by Behnam *et al.* (2015) during storage studies on nisin treated rainbow trout.

Moisture content: The mean moisture content followed a significant ($p<0.05$) decreasing trend with progressive storage period for control as well as products treated with nisin. The decrease in moisture content over the storage period might be due to evaporative loss of some amount of moisture. Similar findings were reported by Bhat *et al.* (2013) in chicken *kababs* during refrigerated storage.

Microbiological characters: The mean values of various microbiological characteristics of the fiber-enriched chicken *Harrisa* treated with nisin are presented in Table-3.

Total plate count: Total plate count (TPC) showed a significant ($p<0.05$) increasing trend from day 0 to day 21 in all the products, however, counts of the products treated with nisin were significantly ($p<0.05$) lower than control on all intervals of storage. The counts were well below the permissible limits for all products up to 14th day of storage and exceeded the limit on 21st day of storage. The reduction in total plate count of nisin treated products was significant as per expectations, since nisin is a broad spectrum bacteriocin with bactericidal activity, even in low concentrations, towards a wide range of Gram-positive bacteria, including *Staphylococcus aureus* and *Listeria monocytogenes* (Parada *et al.* 2007).

Table 3: Effect of nisin on the microbial characteristics of aerobically packed fiber-enriched chicken *Harrisa* under refrigerated C) storage (Mean ± SE)*

Treatment	Storage period (Days)			
	0	7	14	21
Total plate count (log_{10} cfu/g)				
Control	2.50 ± 0.02^{Ba}	3.45 ± 0.02^{Bb}	4.28 ± 0.03^{Bc}	5.45 ± 0.02^{Bd}
(Oat Bran)	2.26 ± 0.01^{Aa}	3.02 ± 0.02^{Ab}	4.09 ± 0.02^{Ac}	5.18 ± 0.04^{Ad}
(Wheat Bran)	2.19 ± 0.05^{Aa}	3.05 ± 0.02^{Ab}	4.03 ± 0.02^{Ac}	5.16 ± 0.03^{Ad}
(Barley Bran)	2.24 ± 0.02^{Aa}	3.08 ± 0.05^{Ab}	4.18 ± 0.03^{Ac}	5.11 ± 0.02^{Ad}
Psychrophilic count (log_{10} cfu/g)				
Control	ND	1.90 ± 0.01^{Ba}	2.50 ± 0.01^{Bb}	3.60 ± 0.02^{Bc}
T_1 (Oat Bran)	ND	1.70 ± 0.01^{Aa}	2.37 ± 0.01^{Ab}	3.42 ± 0.01^{Ac}
T_2 (Wheat Bran)	ND	1.65 ± 0.04^{Aa}	2.33 ± 0.01^{Ab}	3.36 ± 0.01^{Ac}
T_3 (Barley Bran)	ND	1.67 ± 0.03^{Aa}	2.31 ± 0.04^{Ab}	3.38 ± 0.03^{Ac}
Coliform count (log_{10} cfu/g)				
Control	ND	ND	ND	ND
T_1 (Oat Bran)	ND	ND	ND	ND
T_2 (Wheat Bran)	ND	ND	ND	ND
T_3 (Barley Bran)	ND	ND	ND	ND
Yeast and mould count (log_{10} cfu/g)				
Control	ND	1.23 ± 0.05^{a}	2.50 ± 0.07^{b}	3.60 ± 0.17^{c}
T_1 (Oat Bran)	ND	1.35 ± 0.07^{a}	2.59 ± 0.10^{b}	3.70 ± 0.16^{c}
T_2 (Wheat Bran)	ND	1.33 ± 0.08^{a}	2.53 ± 0.08^{b}	3.68 ± 0.13^{c}
T_3 (Barley Bran)	ND	1.41 ± 0.12^{a}	2.55 ± 0.08^{b}	3.55 ± 0.17^{c}

*Mean ± SE with different superscripts in a row wise (lower case alphabet) and column wise (Upper case alphabet) differ significantly ($p<0.05$), n= 6 for each treatment. C = control without nisin, T_1 = chicken *Harrisa* with oat bran and nisin, T_2 = chicken *Harrisa* with wheat bran and nisin, T_3= chicken *Harrisa* with barley bran and nisin, ND = not detected

Psychrophilic count: Psychrophilic counts were not detected on day 0 of storage in control as well as products treated with nisin. Psychrophiles were observed on day 7 and thereafter followed a significant ($p<0.05$) increasing trend, however, counts of the products treated with nisin were significantly ($p<0.05$) lower than control. The counts always remained well below the maximum permissible limits in all products. Cremer and Chipley (1977) described permissible level of psychrophilic count as 4.6 log cfu/g in cooked meat products. A detectable count on day 7 while nil on preceding observations might be attributed to relatively high cooking temperature and to the fact that bacteria generally need some lag phase before active multiplication. A comparatively slow increase in count of products treated with nisin might be attributed to the antimicrobial properties of nisin (Parada *et al.* 2007). Similar results were reported by Behnam *et al*. (2015) who observed significantly ($p<0.05$) lower counts for the products treated with nisin.

Coliform count: The coliforms were not detected throughout the storage period in control as well as products treated with nisin. It could be due to destruction of these bacteria during cooking at 120°C, far above their thermal death point of 57°C. Further, hygienic practices followed during the preparation and packaging of products could be reasons for the absence of coliforms. Similar results were reported by Singh *et al.* (2015) who also reported zero count of coliforms for the meat product heated to such a high temperature.

Yeast and mould count: The yeast and mould counts were not detected on day 7 and thereafter following a significant ($p<0.05$) increasing trend with storage. The counts of the products treated with nisin were comparable ($p>0.05$) with control. These results are supported by the fact that nisin is generally not active against yeasts and fungi (Hampikyan and Ugur 2007).

Sensory parameters: The mean values of various sensory parameters of the fiber-enriched chicken *Harrisa* treated with nisin are presented in Table-4.

Table 4: Effect of nisin on the sensory attributes of aerobically packed fiber-enriched chicken *Harrisa* under refrigerated (4±1°C) storage (Mean ± SE)*

Treatment	Storage period (Days)			
	0	7	14	21
		Appearance and colour		
Control	6.84 ± 0.10^{d}	5.07 ± 0.04^{Ac}	4.02 ± 0.05^{Ab}	3.09 ± 0.03^{Aa}
(Oat Bran)	6.98 ± 0.08^{d}	5.63 ± 0.08^{Bc}	4.53 ± 0.06^{Bb}	3.39 ± 0.08^{Ba}
(Wheat Bran)	7.08 ± 0.04^{d}	5.69 ± 0.07^{Bc}	4.61 ± 0.12^{Bb}	3.49 ± 0.05^{Ba}
(Barley Bran)	6.82 ± 0.12^{d}	5.52 ± 0.07^{Bc}	4.46 ± 0.04^{Bb}	3.42 ± 0.06^{Ba}
		Flavour		
Control	7.19 ± 0.05^{b}	5.10 ± 0.04^{Aa}	Not evaluated	Not evaluated
T_1 (Oat Bran)	7.10 ± 0.05^{b}	5.46 ± 0.03^{Ba}	Not evaluated	Not evaluated
T_2 (Wheat Bran)	7.06 ± 0.07^{b}	5.40 ± 0.03^{Ba}	Not evaluated	Not evaluated
T_3 (Barley Bran)	6.97 ± 0.10^{b}	5.43 ± 0.06^{Ba}	Not evaluated	Not evaluated
		Saltiness		
Control	6.65 ± 0.09	6.62 ± 0.08	Not evaluated	Not evaluated
T_1 (Oat Bran)	6.63 ± 0.06	6.60 ± 0.12	Not evaluated	Not evaluated
T_2 (Wheat Bran)	6.68 ± 0.09	6.61 ± 0.09	Not evaluated	Not evaluated
T_3 (Barley Bran)	6.66 ± 0.09	6.59 ± 0.07	Not evaluated	Not evaluated
		Texture and body		
Control	7.05 ± 0.03^{d}	5.19 ± 0.04^{Ac}	4.14 ± 0.03^{Ab}	3.24 ± 0.04^{a}
T_1 (Oat Bran)	7.14 ± 0.06^{d}	5.56 ± 0.07^{Bc}	4.41 ± 0.03^{Bb}	3.35 ± 0.04^{a}
T_2 (Wheat Bran)	7.12 ± 0.03^{d}	5.53 ± 0.08^{Bc}	4.46 ± 0.04^{Bb}	3.38 ± 0.04^{a}
T_3 (Barley Bran)	7.00 ± 0.06^{d}	5.48 ± 0.04^{Bc}	4.40 ± 0.04^{Bb}	3.29 ± 0.04^{a}
		Overall acceptability		
Control	7.00 ± 0.06^{b}	5.30 ± 0.06^{Aa}	Not evaluated	Not evaluated
T_1 (Oat Bran)	6.92 ± 0.05^{b}	5.75 ± 0.07^{Ba}	Not evaluated	Not evaluated
T_2 (Wheat Bran)	6.99 ± 0.07^{b}	5.84 ± 0.05^{Ba}	Not evaluated	Not evaluated
T_3 (Barley Bran)	6.86 ± 0.09^{b}	5.70 ± 0.05^{Ba}	Not evaluated	Not evaluated

Mean ± SE with different superscripts in a row wise (lower case alphabet) and column wise (Upper case alphabet) differ significantly ($p<0.05$), n= 21 for each treatment. C = control without nisin, T_1 = chicken *Harrisa* with oat bran and nisin, T_2 = chicken *Harrisa* with wheat bran and nisin, T_3 = chicken *Harrisa* with barley bran and nisin

Appearance and colour: The appearance and colour scores showed a significant ($p<0.05$) decreasing trend with storage period, however, the scores were significantly higher for products treated with nisin. Decrease in appearance and colour scores on storage might be due to the pigment and lipid oxidation and non-enzymatic browning resulting from reaction between lipid oxidation products and amino acids (Chandralekha *et al.* 2012). Significantly higher scores for treated products might be attributed to antimicrobial and antioxidant properties of nisin which has the capacity to affect the colour and sensory characteristics of the products. A decrease in appearance and colour scores of meat products on storage was reported by Kandeepan *et al.* (2010).

Flavour: The mean scores for the flavour of the products decreased significantly ($p<0.05$) as the storage period advanced, however, scores for flavour were significantly ($p<0.05$) higher for products treated with nisin. The reduction in flavour could be attributed to the increased lipid oxidation, liberation of fatty acids, increased microbial load and loss of volatile flavour components from spices and condiments with storage (Chandralekha *et al.* 2012). The higher scores for the products treated with nisin may be attributed to the antimicrobial and antioxidant properties of nisin (Behnam *et* 2015, Parada *et al*. 2007). Decline in flavour scores during aerobic storage was also reported by Malav *et al*. (2013) in restructured chicken meat blocks.

Texture and body: The scores for texture and body showed a significant ($p<0.05$) declining trend with storage period, however, scores were significantly ($p<0.05$) higher for products treated with nisin on and after 7th day of storage. The probable reasons for decline in scores may be increased loss of moisture, breakdown of fat, and degradation of muscle fibre proteins by bacterial action. The higher scores for the products treated with nisin may be attributed to the antimicrobial properties of nisin (Behnam *et al.* 2015).

Overall acceptability: Scores for overall acceptability showed a significant ($p<0.05$) decreasing trend with increasing days of storage, however, scores were significantly ($p<0.05$) higher for products treated with nisin on 7th day of storage. The products were not evaluated for some sensory parameters on 14th day and onwards due to increased microbial growth and quality deterioration. Continuous decrease in overall acceptability scores might be reflective of the decline in scores of appearance and colour, flavour, and texture. The significantly ($p<0.05$) higher scores for products treated with nisin correlates well with TBARS and microbiological values and might be attributed to antimicrobial and antioxidant properties of nisin which affect the rate of deterioration of meat products.

The addition of nisin reduced the values of all microbiological parameters significantly and improved the storage quality without adversely affecting the sensory quality of the chicken *Harrisa*. Thus, nisin may be commercially utilized for improving the storage stability of the product.

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