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Research Article

Effect of Mushroom Extract on Storage Stability of Chevon Nuggets at Refrigerated Temperature

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In quest of phytopreservatives, the present experiment was designed to explore potential of edible mushroom extract for storage stability of chevon nuggets. Mushroom extract was added in the formulation at the rate of 0% (control), 5% (T1), 7.5% (T2), and 10% (T3). The shelf-life of products were compared with a control without extract. Physicochemical, antioxidant potential, oxidative changes, microbial quality, and sensory characteristics of these nuggets under refrigeration were assessed for 15 days. The results revealed that incorporation of mushroom extract significantly enhanced the total phenolic and DPPH radical scavenging efficacy of nuggets. Peroxide and TBARS values were also significantly ($P < 0.05$) lower in treatments. Incorporation of extract did not affect the pH, water activity, and sensory characteristics. The microbial proliferation was also significantly ($P < 0.05$) restricted during storage in treatments. Significant differences were evident at 7.5% level of incorporation (T2) which did not differ from that of 10% incorporation (T3). It can be concluded that incorporation of mushroom extract at 7.5% in chevon nuggets efficiently controls deteriorative changes up to 15 days of storage at refrigeration without affecting its sensory quality.

1. Introduction

The bacterial growth and lipid oxidation are the primary causes of loss in food quality and shelf-life reduction. Lipid oxidation is an imperative factor in deterioration of meat products, particularly in fat-rich meat, which consists of higher unsaturated fatty acids. Meat is a nutrient-dense food rich in high-quality lipid, proteins, vitamins, and essential minerals. Therefore, it is a highly perishable food commodity that spoils from the time it is fabricated until it reaches dinner plates; thus, preservation of meat is critical issue in retardation of spoilage, improving quality and extending self-life. Numerous objectionable chemical and enzymatic action leads to formation of unpleasant flavor during storage, making meat products risky for consumption. Synthetic preservative is an artificial preserving material that uses chemicals like nitrite, benzoates, butylated hydroxytoluene, and sorbates. It is well recognized that if these synthetic additives are consumed in the surplus, they produce adverse influence on consumer well-being due to carcinogenic and allergic causes [1]. Outcomes of the above facts is a crucial requirement to substitute these synthetic preservatives with green preservatives.

The processed meat products, like patties, nuggets, and kebabs, are gaining great interest among Indian consumers due to rapid urbanization and demand for nutritional but convenient food items. During the 2019 fiscal year, the livestock industry in India's gross value added from meat products reached over 1.7 trillion Indian rupees [2]. About 22.9 percent of the economic value in livestock sector was represented by this category. Over seven trillion rupees of the nation's GDP that year came from livestock products.

Processed meat products are generally added with chemical preservatives for increasing the shelf-life of meat products, but with recent disillusionment of consumers with chemical additives has piqued researchers and scholars to

explore natural preservatives. Herbs, spices, plant extracts, and essential oils have been used for extending storage life of meat [3–5], dairy [6], and bakery products [7].

Goat meat is rich in proteins, minerals, and fats primarily unsaturated fatty acids which are prone to oxidation and microbial deterioration [8], and edible mushrooms are good source of proteins, crude fiber, ash, and phytochemicals such as phenols, flavonoids, ascorbic acid, and ergothioneine (ESH), an excellent antioxidant. Therefore, the present trial was commenced with the objective to evaluate the effect of mushroom extract on the storage stability of chevon nuggets stored at refrigeration conditions.

2. Materials and Methods

The present study was undertaken at the Department of Livestock Products Technology, College of Veterinary and Animal Sciences, SVPUAT, Meerut, India. Chevon (male barbari leg meat age around 12-15 months) for nugget preparation, mushrooms, and low-density polyethylene (LDPE) packaging materials (200 gauze) for packaging were procured from the local retailer. All chemicals, media, and standards were procured form various manufacturers like Himedia, SRL, and CDH.

2.1. Extract Preparation. Mushroom extract was prepared by drying the finely chopped edible mushrooms at 55 ± 5°C in a hot air oven till the constant dried weight was achieved. It was then pulverized in a food mixer followed by straining. Extraction was done by using magnetic stirrer for which 20 g of the strained powder was taken in a glass flask dissolved in 200 mL distilled water. After finishing, this process supernatant of solution was collected using centrifugation for five minutes at a speed of 2500 rpm. Collected extract was concentrated at 55°C for 150 minutes, with rotary vacuum evaporator for further use. The amount of extract in the concentrated solution was estimated by drying the sample in a preheated hot air oven at 100 ± 5°C. The final concentration used was adjusted to 150 mg/mL on the basis of available literature and preliminary trials. It was then kept in amber-colored bottles at refrigeration storage until use (8 weeks).

2.2. Chevon Nuggets. Chevon nuggets were formulated by executing methodology given by [9] with minor alteration. Deboned meat with removed extraneous fat was comminuted and subjected to mincing (6 mm) in a meat mincer. Minced meat was again run in the mixer (Inalsa, Food Processor, Kitchen Master 1000) along with other ingredients (Table 1). The formed emulsion (approximately 10 kg) was divided into four groups: control (without extract), T1 (with 5 mL/100 gm (*v*/*w*) of mushroom extract in meat emulsion), T2 (with 7.5 mL/100 gm (*v*/*w*) of mushroom extract in meat emulsion), and T3 (with 10 mL/100 gm (*v*/*w*) of mushroom extract in meat emulsion). These groups were separately cooked in a preheated steam cooker without pressure at 110 ± 5°C for 45 min. After cooling, the block was cut into pieces of nuggets and stored in LDPE at refrigeration temperature for storage. Samples were evaluated on every third day.

Table 1: Formulation of mushroom extract-incorporated chevon nuggets.

Ingredients (%)	C	T1	T2	T3
Meat	76.2	76.2	76.2	76.2
Refined oil	6	6	6	6
Chilled water	10	5	2.5	0
Egg yolk	3.0	3.0	3.0	3.0
Salt	1.5	1.5	1.5	1.5
Spices mix.	2.0	2.0	2.0	2.0
Gram dal	3.0	3.0	3.0	3.0
Condiments	3.0	3.0	3.0	3.0
Hydrated soya chunk (1 soya : 3 water)	3.0	3.0	3.0	3.0
STPP	0.3	0.3	0.3	0.3
Mushroom extract (*v*/*w*)	0.0	5.0	7.5	10.0
Nitrite (ppm)	120	120	120	120

Control: without extract; T1: with 5 mL/100 gm (*v*/*w*) of mushroom extract in meat emulsion; T2: with 7.5 mL/100 gm (*v*/*w*) of mushroom extract in meat emulsion; T3: with 10 mL/100 gm (*v*/*w*) of mushroom extract in meat emulsion.

2.3. pH and Water Activity. The pH-meter (ESICO, Model-1012) was calibrated first in buffers at pH 4.01 and 7.01 at room temperature was used to measure the pH values. After homogenizing 5 g of minced chevon nugget samples with 45 mL of deionized water, a glass electrode was immersed directly into the sample as per methods described by [10] and water activity was assessed using Novasina water activity meter.

2.4. Total Phenolics and DPPH Percent Inhibition Activity. Total phenolics [11] and DPPH percent inhibition were assessed to evaluate the antioxidant potential of the nuggets. Folin–Ciocalteu's method with gallic acid as the standard was used for determining total phenolics. Briefly, five-gram nugget sample was triturated with 20 mL of ethanol and methanol in 1 : 1 ratio followed by filtration with Whatman filter paper (No. 42) in a conical flask. The strained sample extract was utilized for both TPC and DPPH analyses. For TPC, 0.6 mL of this filtrate was mixed with 0.3 mL Folin–Ciocalteu's reagent (0.2 N) with proper mixing for five minutes. Then, 2.4 mL sodium carbonate (20%) solution was added and was kept for ten minutes at normal temperature. After incubation, it was filtered and the optical density of filtrate was recorded at 730 nm. The TPC of samples was in terms of μg of gallic acid equivalent (GAE)/g of chevon nuggets.

For DPPH radical percent inhibition, 0.1 mL of sample extract was mixed with 1 mL Tris-HCl buffer (0.1 M, pH 7.4) and 3.9 mL of DPPH reagent (250 μM). It was then subjected to UV-VIS Spectrophotometer for analyzing the absorbency of the sample at 517 nm for time t = 0 min (t_0). This sample was then placed in dark for 20 mins and again analyzed at 517 nm for time t = 20 min (t_{20}). The following equation was applied for estimating the percent DPPH radical inhibition.

$$\text{Scavenging activity}(\%\text{inhibition}) = 100 - (At_{20}/At_0) \times 100. \quad (1)$$

Table 2: Change in pH, water activity, total phenolics content, and DPPH (%) inhibition of mushroom extract-incorporated chevon nuggets.

Groups	0 day	3 days	6 days	9 days	12 days	15 days
pH						
C	6.39 ± 0.02^{Wd}	6.31 ± 0.03^{Wc}	6.20 ± 0.02^{Wab}	6.15 ± 0.01^{Wa}	6.21 ± 0.02^{Wab}	6.26 ± 0.01^{Wbc}
T1	6.45 ± 0.04^{WXc}	6.36 ± 0.02^{Wb}	6.28 ± 0.02^{Xa}	6.25 ± 0.01^{Xa}	6.26 ± 0.01^{Xa}	6.29 ± 0.02^{Xa}
T2	6.50 ± 0.03^{Xd}	6.46 ± 0.01^{Xcd}	6.39 ± 0.01^{Yab}	6.37 ± 0.01^{Ya}	6.40 ± 0.01^{Yab}	6.43 ± 0.01^{Ybc}
T3	6.53 ± 0.03^{Xc}	6.48 ± 0.01^{Xb}	6.44 ± 0.02^{Yab}	6.42 ± 0.02^{Za}	6.45 ± 0.01^{Zab}	6.47 ± 0.01^{Yab}
Water activity (a_W)						
C	0.952 ± 0.004^{e}	0.935 ± 0.005^{Wd}	0.926 ± 0.003^{Wcd}	0.918 ± 0.004^{Wbc}	0.910 ± 0.002^{Wb}	0.898 ± 0.004^{Wa}
T1	0.956 ± 0.006^{d}	0.947 ± 0.004^{XYd}	0.931 ± 0.003^{WXc}	0.924 ± 0.003^{Wbc}	0.917 ± 0.002^{Xab}	0.911 ± 0.003^{Xa}
T2	0.954 ± 0.003^{d}	0.941 ± 0.002^{WXc}	0.937 ± 0.003^{XYc}	0.928 ± 0.003^{Wb}	0.925 ± 0.002^{Yb}	0.916 ± 0.003^{XYa}
T3	0.957 ± 0.003^{e}	0.953 ± 0.003^{Zde}	0.944 ± 0.004^{Ycd}	0.940 ± 0.003^{Xc}	0.931 ± 0.004^{Yb}	0.920 ± 0.002^{Ya}
Total phenolic (mg GAE/g)						
C	0.87 ± 0.03^{We}	0.77 ± 0.01^{Wd}	0.73 ± 0.02^{Wd}	0.67 ± 0.01^{Wc}	0.58 ± 0.01^{Wb}	0.37 ± 0.01^{Wa}
T1	1.29 ± 0.02^{Xf}	1.12 ± 0.03^{Xe}	1.03 ± 0.03^{Xd}	0.92 ± 0.01^{Xc}	0.84 ± 0.02^{Xb}	0.73 ± 0.03^{Xa}
T2	2.27 ± 0.04^{Ye}	2.15 ± 0.05^{Yd}	1.96 ± 0.05^{Yc}	1.82 ± 0.03^{Yb}	1.78 ± 0.03^{Yb}	1.57 ± 0.04^{Ya}
T3	3.57 ± 0.05^{Ze}	3.45 ± 0.03^{Zd}	3.31 ± 0.04^{Zc}	3.21 ± 0.02^{Zc}	2.90 ± 0.05^{Zb}	2.53 ± 0.07^{Za}
DPPH (%) inhibition						
C	25.33 ± 1.23^{We}	22.75 ± 0.69^{Wd}	19.32 ± 0.67^{Wc}	17.08 ± 0.69^{Wbc}	15.96 ± 0.73^{Wb}	11.34 ± 0.45^{Wa}
T1	37.53 ± 1.18^{Xe}	32.58 ± 1.10^{Xd}	30.89 ± 0.86^{Xd}	26.79 ± 0.67^{Xc}	24.21 ± 0.65^{Xb}	20.35 ± 0.54^{Xa}
T2	51.61 ± 1.00^{Ye}	48.30 ± 0.95^{Yd}	44.31 ± 1.32^{Yc}	41.47 ± 0.68^{Yb}	38.99 ± 0.48^{Yb}	34.03 ± 0.71^{Ya}
T3	62.50 ± 0.75^{Ze}	59.44 ± 1.47^{Zd}	56.49 ± 0.63^{Zc}	51.76 ± 0.89^{Zb}	49.89 ± 0.73^{Zb}	44.51 ± 1.03^{Za}

Means values with different superscripts with lowercase letters a, b, c, and d within row and subscripts with uppercase letters W, X, Y, and Z within column differ separately ($P < 0.05$). C: control chevon nugget without mushroom extract; T1: chevon nugget with mushroom extract (5 mL/100 gm) v/w of meat emulsion; T2: chevon nugget with mushroom extract (7.5 mL/100 gm) v/w of meat emulsion; T3: chevon nugget with mushroom extract (10 mL/100 gm) v/w of meat emulsion ($n = 6$).

2.5. Lipid Oxidation. Lipid oxidation during storage was assessed by determining the peroxide value [12] and TBARS values [13].

2.6. Microbial Quality. The microbiological quality of nuggets during storage was evaluated by studying the standard plate count (SPC); psychrophilic, coliform, yeast, and mould counts were estimated using methods described by [14].

2.7. Sensory Evaluation. Sensory evaluation by seven semi-trained panellists (four male nd three female, age between 24 and 45 years) from the university was also performed during storage for analysing the product acceptability at 3-4 PM and the temperature of coded in between 38 and 40°C. Color and appearance, texture, flavor, juiciness, and overall acceptability were rated on 9-point hedonic scale, where scale rated as 1 = extremely poor, 5 = neither like nor dislike, and 9 = excellent.

2.8. Statistical Analysis. The whole experiment was replicated thrice; while, samples were taken in duplicate during analysis ($n = 2 \times 3 = 6$). However, for sensory parameters seven trained sensory tasters evaluated the product for whole experiment ($n = 7 \times 3 = 21$). 'SPSS-22.0' software, SPSS, Inc., Chicago IL, USA, was used for statistical analysis of data recorded during experiment. Two-way analysis of variance was used and means were compared by using Duncan's multiple range tests and homogeneity tests.

3. Results and Discussion

3.1. Change in pH and Water Activity (a_W) of Mushroom Extract-Incorporated Chevon Meat Nuggets. The pH values varied considerably ($P < 0.05$) at each day of interval and among all groups during storage (Table 2). Initially, pH values for all groups followed declining trend up to 9th day; after that, it increased considerably throughout storage. There was a positive relationship between the pH values and mushroom extract concentration, which may be due to the little more pH value of mushroom extract. Similar to our findings, [15] reported that addition of mushroom powder in meat products exhibited increase in pH values than that in the control group. Initial decrease in pH values for all samples might be due to proliferation of lactic acid producing microbes which causes formation of lactic acid followed by the proliferation of proteolytic microorganism leading to generation of ammoniacal compounds due deamination. A similar result was also reported by [16] for chevon meat products.

Water activity values remained comparable on the first day of storage among all groups. T3 had comparable highest a_W value than other groups throughout the storage (Table 2). Water activity value decreased significantly ($P < 0.05$)

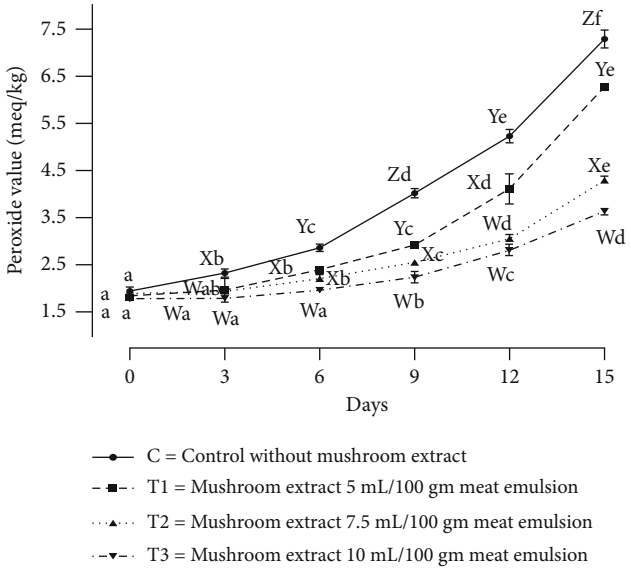

Figure 1: Change in peroxide value (meq/kg) of mushroom extract incorporated chevon nuggets. Means values with different superscripts with lowercase letters a, b, c, and d and subscripts with uppercase letters W, X, Y, and Z differ separately ($P < 0.05$). C: Control chevon nugget without mushroom extract; T1: chevon nugget with mushroom extract (5 mL/100 gm) v/w of meat emulsion; T2: chevon nugget with mushroom extract (7.5 mL/100 gm) v/w of meat emulsion; T3: chevon nugget with mushroom extract (10 mL/100 gm) v/w of meat emulsion ($n = 6$).

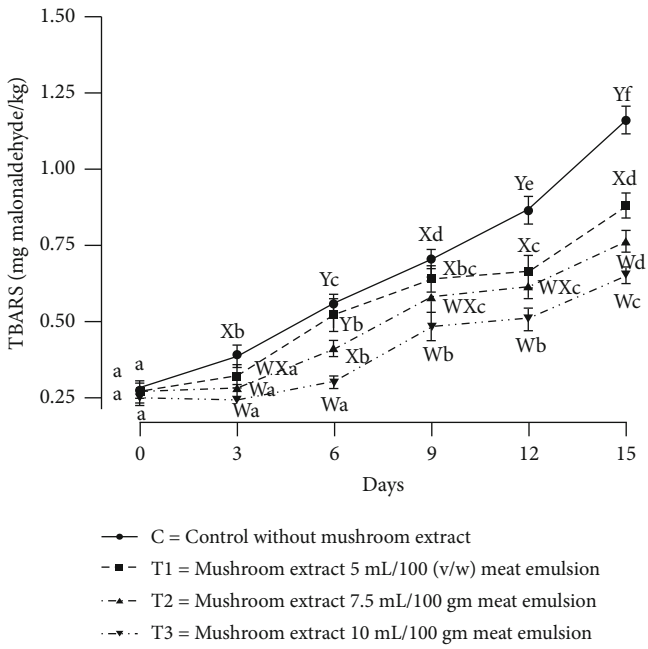

Figure 2: Change in TBARS numbers (mg malonaldehyde/kg) of mushroom extract incorporated chevon nuggets. Mean values with different superscripts with lowercase letters a, b, c, and d and subscripts with uppercase letters W, X, Y, and Z differ separately ($P < 0.05$). C: Control chevon nugget without mushroom extract, T1: chevon nugget with mushroom extract (5 mL/100 gm) v/w of meat emulsion; T2: chevon nugget with mushroom extract (7.5 mL/100 gm) v/w of meat emulsion; T3: chevon nugget with mushroom extract (10 mL/100 gm) v/w of meat emulsion ($n = 6$).

irrespective of treatments among all groups though, the rate of a_W decrement was significantly ($P < 0.05$) lower in treated samples. The higher a_W value in treated samples could be attributed to the lower oxidation of protein leading to better water binding capacity and also to antimicrobial activity of mushroom extract that decline the proliferation of microbes. Verma et al. [17] also reported decrease in water activity value for meat products storage at refrigerated temperature.

3.2. Change in Total Phenolics Content and DPPH (%) Inhibition of Mushroom Extract-Incorporated Chevon Nuggets. In the beginning, the total phenolics content in the control chevon nuggets, as well as in mushroom extract-added chevon nuggets, was between 0.87 and 3.57 mg GAE/g, and the values differed significantly ($P < 0.05$) among treatments (Table 2). Compared to the mushroom extract-added chevon nuggets, the total phenolic contents of control chevon nuggets were significantly ($P < 0.05$) lower during entire storage. Total phenolic contents in control chevon nugget decreased from 0.87 to 0.37 mg GAE/g, whereas total phenolic contents in T3 sample prepared with (10 mL/100 g) decreased slowly and maintained 3.57 to 2.53 mg GAE/g during the storage period. The decrease in total phenolic content during the storage might be due to the utilization of phenolic compounds in stabilization of free radical's which are formed during the oxidation of lipid and protein molecule. Earlier studies have also stated that total phenolics reduce during storage of meat products prepared with incorporation of walnut leaf powder [18].

According to the perusal of results, DPPH (%) inhibition varied significantly ($P < 0.05$) among all treatments at each day of storage. The results revealed that the highest DPPH (%) inhibition was recorded in the T3 group, while lowest DPPH (%) inhibition was observed in the control. The results of DPPH % inhibition (Table 2) exhibited that the DPPH inhibition value decreased significantly ($P < 0.05$) among all groups as the storage period increased. The DPPH (%) inhibition activity of mushroom extract increased progressively with concentration-dependent manner. At 15th day of storage, the highest of DPPH % inhibition was observed in the T3 group added with mushroom extract with a concentration of 10 mL/100 g (44.51%) and the lowest values was measured in control group (11.34%). The results revealed that addition of mushroom extract increased the DPPH % inhibition activity and prolong the shelf-life of chevon nuggets during storage. These results are in accordance with findings reported by [19]. The DPPH inhibition assay of mushroom extract is associated with the presence of phenolic and flavonoid compounds. These findings are compatible with our outcomes estimated in total phenolic compounds and lipid oxidation. Similar results of decrease in DPPH scavenging activity during storage in meat products formulated with oregano and bay have also been observed [7].

3.3. Change in Lipid Oxidation of Mushroom Extract-Incorporated Chevon Nuggets. The lipid oxidation process follows a bell-shaped pattern and is characterized by lag

Table 3: Change in microbial quality of mushroom extract incorporated chevon nuggets.

Groups	0 day	3 days	6 days	9 days	12 days	15 days
Standard plate counts (cfu/g)						
C	2.65 ± 0.08^{a}	2.96 ± 0.06^{b}	3.46 ± 0.12^{Xc}	4.10 ± 0.12^{Xd}	4.64 ± 0.08^{Ye}	5.79 ± 0.06^{Yf}
T1	2.59 ± 0.07^{a}	2.83 ± 0.08^{a}	3.20 ± 0.17^{WXb}	3.72 ± 0.10^{Wc}	4.37 ± 0.05^{Xd}	5.39 ± 0.10^{Xe}
T2	2.60 ± 0.06^{a}	2.85 ± 0.09^{b}	3.09 ± 0.09^{Wc}	3.56 ± 0.09^{Wd}	4.15 ± 0.04^{We}	5.26 ± 0.07^{Xf}
T3	2.58 ± 0.07^{a}	2.71 ± 0.10^{a}	2.98 ± 0.08^{Wb}	3.42 ± 0.07^{Wc}	4.10 ± 0.08^{Wd}	4.86 ± 0.04^{We}
Psychrophilic counts (cfu/g)						
C	ND	ND	2.21 ± 0.14^{a}	2.63 ± 0.09^{Xb}	3.00 ± 0.10^{Xc}	3.33 ± 0.07^{Yd}
T1	ND	ND	2.38 ± 0.06^{a}	2.52 ± 0.10^{WXa}	2.85 ± 0.08^{Xb}	2.99 ± 0.08^{Xb}
T2	ND	ND	2.22 ± 0.09^{a}	2.29 ± 0.07^{Wab}	2.52 ± 0.09^{Wbc}	2.76 ± 0.11^{WXc}
T3	ND	ND	ND	2.31 ± 0.09^{Wa}	2.39 ± 0.10^{Wab}	2.55 ± 0.09^{Wb}
Coliform counts (cfu/g)						
C	ND	ND	ND	1.44 ± 0.06^{a}	1.74 ± 0.15^{Xa}	2.30 ± 0.10^{Xb}
T1	ND	ND	ND	1.39 ± 0.14^{a}	1.59 ± 0.12^{WXa}	1.67 ± 0.13^{Wb}
T2	ND	ND	ND	1.32 ± 0.18^{a}	1.42 ± 0.14^{Wab}	1.64 ± 0.12^{Wb}
T3	ND	ND	ND	1.29 ± 0.13^{a}	1.30 ± 0.06^{Wa}	1.58 ± 0.11^{Wb}
Yeast and mould counts (cfu/g)						
C	ND	ND	ND	1.79 ± 0.12^{a}	2.21 ± 0.09^{Xb}	2.63 ± 0.04^{Yc}
T1	ND	ND	ND	1.53 ± 0.10^{a}	1.92 ± 0.11^{WXb}	2.35 ± 0.12^{Xc}
T2	ND	ND	ND	1.50 ± 0.09^{a}	1.83 ± 0.12^{Wb}	1.99 ± 0.09^{Wb}
T3	ND	ND	ND	1.52 ± 0.06^{a}	1.66 ± 0.07^{Wab}	1.74 ± 0.06^{Wb}

Means values with different superscripts with lowercase letters a, b, c, and d within row and subscripts with uppercase letters W, X, Y, and Z within column differ separately ($P < 0.05$). C: control chevon nugget without mushroom extract; T1: chevon nugget with mushroom extract (5 mL/100 gm) *v/w* of meat emulsion; T2: chevon nugget with mushroom extract (7.5 mL/100 gm) *v/w* of meat emulsion; T3: chevon nugget with mushroom extract (10 mL/100 gm) *v/w* of meat emulsion ($n = 6$).

phase perceived via log and decline pattern. The status of lipid oxidation of meat products may be confirmed by estimation of primary and secondary lipid oxidation end products. The effect of incorporation mushroom extract on the oxidative stability of chevon nuggets was assessed through estimation of PV (Figure 1) and TBARS number (Figure 2) for 15 days at 3-day interval. Among the groups, PV and TBARS numbers varied significantly ($P < 0.05$) and the T3 sample recorded lower lipid oxidation. Both PV and TBARS values rose during storage of chevon nuggets; however, the lipid oxidation rate was lower in the treated groups than that in the control. There was a negative correlation between the concentration of mushroom extract and lipid oxidation that might be due to the presence of phytochemicals like polyphenolics and ergothioneine substances. Researchers [20] reported that mushroom extract encompasses phytochemicals, and these bioactive compounds have shown to efficiently inhibit lipid oxidation in food products. Ergothioneine is the principal compound that prevents generation of the superoxide radicals, while phenolic compounds may sequester the transitional metal ions as well as capture free radicals [21]. Tao et al. [5] also reported that incorporation of mushroom extracts suppresses the rate of lipid oxidation in fish products stored at low temperature. The rate of lipid oxidation mushroom extract might be due to reduced formation of free radicals, stabilization of reacting oxygen molecule, and chelation of transition metal ions which are mainly responsible for lipid oxidation of meat and meat products. The current study found that the mushroom extracts used are effective on delaying lipid peroxidation in goat meat nuggets stored under refrigeration. Mushroom extract's ability to prevent lipid oxidation and retard microbial proliferation is most likely related to their total phenolic compound content. Phenolic antioxidants prevent formation of free radicals, which react with or absorb oxygen during autoxidation process, delaying the cascade reaction of lipid oxidation.

3.4. Change in Microbial Quality of Mushroom Extract-Incorporated Chevon Nuggets. The mean values of microbial quality of chevon nuggets during storage are given in (Table 3). It is evident that, although most of the microbial (SPC, psychrophile, coliforms, and yeast and mould counts) values were comparable on initial days of study, by the end of study, significantly higher counts were noted in the control than treatments indicating antimicrobial effect of the mushroom extract. Novakovic et al. [22] also observed restricted mesophilic growth by incorporation of *B. edulis* mushroom in frankfurters stored at refrigeration temperature. Similarly, [23] reported significantly lower aerobic plate counts in frankfurters added with 1-1.2% shiitake mushroom powder, while [24] observed significant antimicrobial effect of shiitake stipe extract in fermented sausages against *E coli*. Phtyocompounds such as phenolic acids, flavonoids, guggulsterones,

Table 4: Change in sensory quality of mushroom extract incorporated chevon nuggets.

Groups	0 day	3 days	6 days	9 days	12 days	15 days
Color & appearance						
C	8.29 ± 0.16^{f}	7.86 ± 0.15^{e}	7.56 ± 0.10^{Wd}	7.14 ± 0.10^{Wc}	6.50 ± 0.12^{Wb}	5.82 ± 0.10^{Wa}
T1	8.21 ± 0.13^{c}	8.04 ± 0.09^{c}	7.93 ± 0.08^{Xc}	7.39 ± 0.19^{WXb}	7.07 ± 0.13^{Xb}	6.61 ± 0.08^{Xa}
T2	8.18 ± 0.10^{c}	8.11 ± 0.08^{c}	8.00 ± 0.12^{Xc}	7.50 ± 0.10^{WXb}	6.68 ± 0.10^{Wa}	6.71 ± 0.11^{XYa}
T3	8.25 ± 0.10^{c}	8.14 ± 0.10^{c}	8.04 ± 0.04^{Xc}	7.71 ± 0.11^{Yb}	7.14 ± 0.08^{Xa}	6.96 ± 0.12^{Ya}
Flavor						
C	8.25 ± 0.08^{f}	7.89 ± 0.05^{e}	7.39 ± 0.10^{d}	6.82 ± 0.11^{Wc}	6.11 ± 0.09^{Wb}	5.75 ± 0.10^{Wa}
T1	8.15 ± 0.09^{c}	7.96 ± 0.12^{c}	7.61 ± 0.13^{b}	7.32 ± 0.08^{Xb}	6.82 ± 0.11^{XYa}	6.54 ± 0.12^{Ya}
T2	8.11 ± 0.13^{f}	7.75 ± 0.08^{e}	7.43 ± 0.08^{d}	7.11 ± 0.10^{Xc}	6.64 ± 0.14^{Xb}	6.18 ± 0.16^{Xa}
T3	8.00 ± 0.13^{d}	7.79 ± 0.15^{cd}	7.50 ± 0.08^{bc}	7.32 ± 0.11^{Xb}	6.96 ± 0.07^{Ya}	6.75 ± 0.12^{Ya}
Texture						
C	8.21 ± 0.09^{e}	7.86 ± 0.12^{d}	7.64 ± 0.10^{d}	7.00 ± 0.12^{Wc}	6.21 ± 0.09^{Wb}	5.50 ± 0.13^{Wa}
T1	8.14 ± 0.05^{e}	7.89 ± 0.11^{d}	7.71 ± 0.09^{d}	7.14 ± 0.08^{Wc}	6.86 ± 0.10^{Xb}	6.39 ± 0.08^{Xa}
T2	8.25 ± 0.10^{f}	8.00 ± 0.09^{e}	7.79 ± 0.14^{d}	7.29 ± 0.09^{WXc}	6.93 ± 0.05^{Xb}	6.64 ± 0.11^{Xa}
T3	8.29 ± 0.07^{f}	8.07 ± 0.10^{e}	7.75 ± 0.12^{d}	7.46 ± 0.11^{Xc}	7.04 ± 0.07^{Xb}	6.71 ± 0.12^{Xa}
Juiciness						
C	8.18 ± 0.10^{f}	7.82 ± 0.08^{e}	7.57 ± 0.10^{d}	6.93 ± 0.09^{Wc}	6.39 ± 0.08^{Wb}	5.58 ± 0.07^{Wa}
T1	8.21 ± 0.09^{e}	7.86 ± 0.10^{d}	7.61 ± 0.12^{d}	7.21 ± 0.10^{Xc}	6.89 ± 0.07^{Xb}	6.57 ± 0.13^{Xa}
T2	8.14 ± 0.08^{e}	8.00 ± 0.08^{ed}	7.75 ± 0.10^{d}	7.32 ± 0.11^{XYc}	6.96 ± 0.12^{Xb}	6.61 ± 0.10^{Xa}
T3	8.11 ± 0.08^{e}	7.96 ± 0.07^{de}	7.79 ± 0.11^{d}	7.50 ± 0.08^{Yc}	7.07 ± 0.10^{Xb}	6.71 ± 0.11^{Xa}
Overall acceptability						
C	8.21 ± 0.09^{e}	7.96 ± 0.11^{e}	7.68 ± 0.10^{d}	7.29 ± 0.11^{c}	6.68 ± 0.08^{Wb}	6.04 ± 0.12^{Wa}
T1	8.18 ± 0.13^{e}	7.93 ± 0.11^{d}	7.75 ± 0.09^{cd}	7.54 ± 0.07^{c}	$6.82 \pm .010^{Wb}$	6.43 ± 0.08^{Xa}
T2	8.25 ± 0.10^{e}	8.07 ± 0.05^{de}	7.93 ± 0.08^{d}	7.57 ± 0.11^{c}	7.11 ± 0.05^{Xb}	6.64 ± 0.10^{Xa}
T3	8.14 ± 0.08^{e}	8.00 ± 0.09^{de}	7.82 ± 0.10^{d}	7.54 ± 0.07^{c}	$7.14 \pm .010^{Xb}$	6.68 ± 0.08^{Xa}

Means values with different superscripts with lowercase letters a, b, c, and d within row and subscripts with uppercase letters W, X, Y, and Z within column differ separately ($P < 0.05$). C: control chevon nugget without mushroom extract; T1: chevon nugget with mushroom extract (5 mL/100 gm) *v/w* of meat emulsion; T2: chevon nugget with mushroom extract (7.5 mL/100 gm) *v/w* of meat emulsion; T3: chevon nugget with mushroom extract (10 mL/100 gm) v/w of meat emulsion ($n = 21$).

guggulterols, terpenoids, phenolic acids, and lignans might be attributed to the better antimicrobial potential of treatments than the control [25, 26]. Significantly higher values in SPC and psychrophile count was observed from day 9 in the control than treatments, while a significant difference in coliform and yeast and mould count was observed on the last day. Among treatments, T1 and T2 did not show significant differences in all except yeast and mould counts indicating antimycotic efficiency only at higher concentrations.

3.5. Change in Sensory Evaluation of Mushroom Extract-Incorporated Chevon Nugget. The sensory characteristics of chevon nuggets did not show significant difference in all studied parameters viz. color and appearance, flavor, texture, juiciness, and overall acceptability initially (Table 4). But with the commencement of storage, significant differences were observed in color and appearance from day 6. Distinct changes in flavor were observed from day 9 where treatments were rated higher than the control. Better maintained flavor scores in treatments might be attributed to the "umami" compounds in mushrooms. Qing et al. [27] in a study on edible mushrooms reported improved flavor of beef paste with identifiable 35 volatile compounds which were attributed to the flavoring compounds and enzymes in mushrooms and were also implicated for the formation of flavor compounds in meat products. Twelve days of storage led to microbial and biochemical changes resulting in lower scores in all except T3 where the values were above 7 other than for flavor. The higher mushroom extract concentration maintained better quality characteristics than the rest. Similarly, [28] also observed good overall liking influenced by the juiciness, tenderness, and flavor of beef burgers incorporated with higher levels (10% and 15%) *Agaricus bisporus* mushroom as fat replacer. On the last day of storage, all sensory parameters in the control received scores lower than 6 except for overall acceptability which was significantly lower than those of treatments. The sensorial qualities were significantly better in treatments than the control owing to the antioxidative and antimicrobial potential of mushroom extract. Akesowan's [29] incorporation of shiitake mushroom powder reduced the rate of lipid oxidation due to presence phenolic compounds in frozen stored chicken nuggets.

4. Conclusions

The results of the present study indicates that incorporation of mushroom extract in chevon nugget formulation drastically increased the total phenolic content and DPPH radical inhibition activity which was more than double the value of the control and in T2 and T3. Consequently, the effect was also evident on the peroxide and TBARS value of stored nuggets which was significantly lower in treatments than the control. The mushroom extract did not affect the pH, water activity, microbial counts, and sensory characteristics initially but the preservative effect was significantly evident during storage where all the studied parameters were limited in treatments corresponding to the level of incorporation. As significant differences were evident at 7.5% level of incorporation (T2) which did not differ from that of 10% incorporation (T3), it can be concluded that mushroom extract being an excellent source of phytochemicals can stabilize oxidative process and inhibit microbial proliferation and its incorporation at 7.5% can efficiently be used for preserving chevon nuggets under refrigeration storage.

Data Availability

Data are included in the form of tables and graphs.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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