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Quality and Acceptability of Meat Nuggets with Fresh *Aloe vera* Gel

V. Rajkumar, Arun K. Verma, G. Patra[1], S. Pradhan[1], S. Biswas[1], P. Chauhan[2], and Arun K. Das[2,*]
Goats Products Technology Laboratory, ICAR-Central Institute for Research on Goats, Farah, Mathura 281122, India

ABSTRACT: *Aloe vera* has been used worldwide for pharmaceutical, food, and cosmetic industries due to its wide biological activities. However, quality improvement of low fat meat products and their acceptability with added *Aloe vera* gel (AVG) is scanty. The aim of this study was to explore the feasibility of using fresh AVG on physicochemical, textural, sensory and nutritive qualities of goat meat nuggets. The products were prepared with 0%, 2.5%, and 5% fresh AVG replacing goat meat and were analyzed for proximate composition, physicochemical and textural properties, fatty acid profile and sensory parameters. Changes in lipid oxidation and microbial growth of nuggets were also evaluated over 9 days of refrigerated storage. The results showed that AVG significantly ($p<0.05$) decreased the pH value and protein content of meat emulsion and nuggets. Product yield was affected at 5% level of gel. Addition of AVG in the formulation significantly affected the values of texture profile analysis. The AVG reduced the lipid oxidation and microbial growth in nuggets during storage. Sensory panelists preferred nuggets with 2.5% AVG over nuggets with 5% AVG. Therefore, AVG up to 2.5% level could be used for quality improvement in goat meat nuggets without affecting its sensorial, textural and nutritive values. (**Key Words:** Goat Meat Nuggets, *Aloe vera* Gel, Physicochemical Property, Texture Profile Analysis, Fatty Acid Profile, Sensory Characteristics)

INTRODUCTION

Ingredients for meat processing are broadly categorized into meat and non-meat parts. Proportion of both the categories as well as kind of non-meat ingredients can significantly influence the technical, physicochemical, nutritional and sensory characteristics of meat product. Extenders or fillers are one of the important non-meat ingredients which affect the water as well as fat binding capacity, emulsifying capacity, product yield, colour, and texture. They decrease the rubberiness in meat products and improve sliceability besides minimizing the cost of the formulations. Additionally several extenders or binder can be a vital source of bioactive and functional components as well as micronutrients. Fresh *Aloe vera* gel (AVG) addition in the meat products could also contribute some of these attributes. It is extensively used as health foods for medicinal purposes besides its use as preservative for foods since time in memorial (Crosswhite and Crosswhite, 1984).

Aloe vera (*Aloe barbadensis* Miller), botanically is a member of the family Liliaceae. It is a short stemmed succulent, perennial herb with more than 360 different species and is cultivated in the dry regions of North America, Europe and Asia. Resurgence of interest in AVG is due to the possibility of distinct physiological effects in therapeutic purpose (Grindlay and Reynolds, 1986). The numerous beneficial effects attributed to Aloe gel, its production is an emerging industry for making cosmetics, functional food, and drugs. Its medicinal properties have attracted the people for the cultivation in other areas with different climatic conditions (Rodriguez et al., 2010). The AVG is sold commercially worldwide as an ingredient to a wide range of health care, cosmetic and therapeutic products (Eshun and He, 2004; Rajasekaran et al., 2005). Hypoglycemic effect, treatment of peptic ulcers, tumor and gastrointestinal dysfunctions, immunologic, antioxidant, and anti-neoplastic, anti-cancer and anti-viral effects have

* Corresponding Author: Arun K. Das. Tel: +91-033-25582965, Fax: +91-033-25565725, E-mail: arunlpt@gmail.com
[1] Department of Livestock Products Technology, WBUAFS, Kolkata 700037, India.
[2] ICAR-Indian Veterinary Research Institute, Eastern Regional Station, Kolkata 700037, India.
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been attributed to the oral use of AVG (Choi and Chung, 2003; Valverde et al., 2005; Rodriguez et al., 2010; Saritha et al., 2010). *Aloe vera* has also been shown to be a potential therapeutic agent for the treatment of sepsis and hepatotoxicity (Yun et al., 2009).

In the food industry, Aloe gel has been used as a source of functional foods and as an ingredient in other food products, for the production of gel-containing health drinks and beverages (Hamman, 2008), as an edible coating to preserve grape fruit quality (Valverde et al., 2005), as a natural antioxidant and antibacterial agent (Saritha et al., 2010). Recently, (Soltanizadeh and Ghiasi-Esfahani, 2015) observed the quality improvement of low meat beef burger added with AVG powder. However, there is very little or no scientific evidence regarding use of fresh AVG as fillers/extenders in meat products and its effects on their quality, acceptability and storage stability. Therefore, it would be interesting to observe the feasibility of fresh AVG incorporation in meat products and assess its influence in meat products. The purpose of this study was to evaluate the effect of AVG on physicochemical, textural, sensory and nutritive qualities of goat meat nuggets.

MATERIALS AND METHODS

Materials

Aloe vera leaves, collected from the Institute's farm were washed and traditional hand filleting method was adopted to harvest the parenchymatous gel inside. Gel was collected, washed several times with chilled distilled water and preserved for further use. All other chemicals used in this study were of analytical grade purchased from Merck Chemical Company, Darmstadt, Germany.

Preparation of nuggets

Goat meat nuggets were prepared as per the procedure outlined by Das et al. (2015). Goat meat was procured from the institute's experimental slaughter house and was kept under frozen storage at –18°C till the product processing. Minced meat was obtained using a meat mincer (Tallers Ramon Model P-22, Barcelona, Spain) and all the ingredients were thoroughly mixed and chopped by a bowl chopper (Seydelmann K20 Ras, Stuttgart, Germany) to prepare the emulsion for each treatment. AVG was incorporated in the product formulation at two different levels i.e., 2.5% and 5.0% and evaluated against control (without AVG). Goat meat nuggets were packed in LDPE pouches using a Roschermatic packaging machine (Roscher Geba, Bersenbruck, Germany) for further analysis. In order to evaluate the effect of AVG on the quality of goat meat nuggets during storage, nuggets were kept at refrigerated temperature (4°C±1°C) for 9 days and thiobarbituric acid reactive substances (TBARS) number and microbial counts (total plate count and psychrotrophs) were studied. The experiment was replicated thrice.

Proximate analysis

The moisture, protein, fat and ash content of AVG, emulsion and goat meat nuggets were determined according to the AOAC (1995) methods. Moisture content was estimated in an oven at 105°C until the weight became constant. Total crude protein was determined by the Kjeldahl method, lipid content was analyzed according to the Soxhlet method and ash content was measured in a muffle furnace. The carbohydrate of *Aloe vera* was estimated by difference.

pH, emulsion stability and cooking yield

For pH estimation, 10 g sample from Aloe gel, emulsion and nuggets was blended in a homogenizer (Model PT-MR-2100, Kinematica AG, Lucerne, Switzerland) with 50 ml distilled water for a minute. A digital pH meter (Systronics, μ pH system 361, Delhi, India) was used to measure the pH value. Approximately 25 g of meat emulsion was heated in a polypropylene bag at 80°C for 20 min in a water bath to measure the emulsion stability percent. Cooked samples were cooled and weighed after draining out the exudate. To get product yield, weight of meat block before and after cooking was recorded and was calculated and expressed as percentage.

Texture profile analysis

Textural properties of nuggets were performed using a texturometer (Stable Micro System Model TA.XT 2i/25, Godalming, Surrey, UK) with central cores of six pieces of each sample (1.5 cm^3) which were compressed twice to 80% of the original height with a crosshead speed of 2 mm/s (Das et al., 2008b). Warner-Bratzler blade, which is attached to texture analyzer was used to measure shear force (N/cm^2) and work of shearing (Ns). Six cores (1.5 cm^3) from nuggets were taken for texture analysis. Force needed to cut the nuggets (shear force) and the work required to move the blade through the nuggets (work of shearing) were recorded.

Fatty acid profile

A direct and simple method of O'Fallon et al. (2007) was followed for fat extraction and preparation of fatty acid methyl esters (FAME) of nuggets. The fatty acid composition of the FAME was determined by capillary gas chromatography on a CP-6173, 60 m×0.25 mm ×0.20 μm capillary column (Varian) installed on a Thermo Scientific Ceres 800 plus gas chromatograph fitted with Automatic sampler AI3000 (Thermo Fisher Scientific Inc, Atlanta, GA,

USA), integrator and flame ionization detector. The initial oven temperature was 120°C, held for 5 min, subsequently increased to 240°C at a rate of 2°C/min. Nitrogen was used as the carrier gas at a flow rate of 1 mL/min. Both the injector and the detector were set at 260°C. The split ratio was 30:1. Fatty acids were identified by comparing their retention times with the fatty acid methyl standards and were expressed as percentage of total fatty acids.

Sensory evaluation

Experienced panelists (fifteen members) evaluated goat meat nuggets on sensory evaluation proforma for appearance, flavour, juiciness, texture and overall acceptability. 8 points descriptive scale where eight (8) denoted extremely desirable and one (1) denoted extremely poor (Das et al., 2008a) was used to evaluate goat meat nuggets. Nuggets were served randomly to the panelists on plates after warming with a microwave oven. Filtered water was provided to the panelists to rinse mouth between samples.

Thiobarbituric acid reactive substances number

Lipid per-oxidization in nuggets was recorded by measuring TBARS at an interval of 3 days during refrigerated storage. TBARS number (mg malonaldehyde/kg) of nuggets was estimated using the extraction method outlined by Witte et al. (1970) with slight modifications, as the slurry was centrifuged at 3,000 g for 10 min (Biofuge Primo R, Heraeus, Osterode, Germany) instead of filtration through Whatman No. 42 (Verma et al., 2013).

Microbiological analysis

Nugget (about 10 g) was ground in a sterile pestle and mortar with 90 mL sterile 0.1% peptone water. Appropriate dilutions were plated, in duplicate, on the growth media by using pour plate method. For total plate count and psychrotrophs count, plate count agar was used. The plates were incubated at 35°C±2°C for 24 h for total plate count and at 4°C±1°C for 10 to 14 days for psychrotrophs count. Plates showing 30 to 300 colonies after incubation were counted and expressed as $\log_{10}$ colony-forming unit/g sample (APHA, 1984).

Statistical analysis

Three replications of the study were performed and in each replication, physicochemical parameters were evaluated in triplicates (n = 9); Six samples from each treatment were measured for texture profile analysis (n = 18); 15 Filled sensory proforma for each treatment were collected (n = 45); Fatty acid profile, total plate count, psychrotroph count and TBARS number were evaluated in duplicate (n = 6). One-way analysis of variance (ANOVA) with SPSS software (version 14.0) was used for calculation of different mean values, whereas TBARS number and microbiological qualities were analyzed using two-way ANOVA with treatment and storage time as main effects. Statistical significance was identified at the 95% confidence level ($p<0.05$). The values were presented as mean along with standard error (Mean±standard error).

RESULTS AND DISCUSSION

Proximate composition

In this study, the moisture, protein, fat and ash contents of fresh AVG were 98%, 0.9%, 0.03%, and 0.24%, respectively (supplementary data). Protein, fat and ash percentage of AVG were within the ranges reported by various workers (Boudreau and Beland, 2006; Miranda et al., 2009; Rodriguez et al., 2010). Fresh gel had an acidic pH value of 4.9 which was similar to those reported by various workers (Eshun and He, 2004; Miranda et al., 2009). The major fraction in the gel carbohydrate is composed of free sugars, soluble polysaccharides, and fibre (Choi and Chung, 2003). Hamman (2008) reported that two major sugars, namely fructose and glucose present in the gel.

Table 1 reveals moisture, fat, protein and ash contents of the meat emulsion and cooked nuggets containing different concentrations of AVG. The AVG inclusion significantly ($p<0.05$) increased moisture content and reduced protein content specially at 5% level both in emulsion and cooked goat meat nuggets. Higher moisture content in emulsion and

Table 1. Effect of *Aloe vera* gel on pH, emulsion stability, proximate composition of emulsion and goat meat nuggets

Parameters	Control nuggets	2.5 AVG nuggets	5 AVG nuggets
Emulsion			
pH	6.37±0.01[a]	6.32±0.01[b]	6.29±0.01[b]
Emulsion stability (%)	91.63±1.43	91.17±0.86	90.79±1.25
Moisture (%)	68.09±0.37[b]	69.15±0.75[b]	70.88±0.32[a]
Fat (%)	8.90±0.08	9.00±0.18	9.03±0.06
Protein (%)	13.14±0.23[a]	12.55±0.31[a]	11.65±0.19[b]
Ash (%)	2.82±0.03	2.82±0.04	2.73±0.06
Goat meat nuggets			
pH	6.43±0.01[a]	6.40±0.02[ab]	6.37±0.02[b]
Cooking yield (%)	95.74±0.72[a]	95.98±0.39[a]	93.48±0.32[b]
Moisture (%)	66.42±0.13[c]	68.28±0.22[b]	68.98±0.21[a]
Fat (%)	10.71±0.29	10.22±0.13	9.89±0.18
Protein (%)	14.08±0.57[a]	13.20±0.13[ab]	12.68±0.14[b]
Ash (%)	2.94±0.04	2.96±0.01	2.90±0.06

AVG, *Aloe vera* gel.

Control nuggets, nuggets without AVG; 2.5 AVG nuggets, goat meat nuggets with 2.5% AVG; 5 AVG nuggets, goat meat nuggets with 5% AVG.

[ab] Means bearing different superscripts in a row differ significantly ($p<0.05$).

nuggets was probably due to high moisture content of gel (98%). Significant reduction in the protein content of nuggets with 5% AVG could be attributed to replacement of lean meat which contains much higher protein (18% to 19%) with respect to the protein content (0.9%) in AVG. According to Das et al. (2006) protein content of the meat product decreased with increasing amount of hydrated soy paste. No significant effect was observed on the fat and ash contents of nuggets when compared with the control. Recently, Soltanizadeh and Ghiasi-Esfahani (2015) did not find any significant effect on proximate composition of low meat beef burgers due to addition of *Aloe vera* powder. This could be due to different physical form of *Aloe vera* they used.

pH, emulsion stability and cooking yield

Use of fresh Aloe gel significantly reduced ($p<0.05$) the pH value of emulsion and goat meat nuggets at both 2.5% and 5% levels (Table 1). Emulsion and nuggets with 5% AVG showed the lowest pH values. *Aloe vera* has an acidic pH that reduces the pH of the meat products (Soltanizadeh and Ghiasi-Esfahani, 2015). No significant effect of AVG incorporation on emulsion stability was observed. Goat meat nuggets containing 2.5% AVG exhibited significantly ($p<0.05$) improved cooking yield than nuggets with 5% AVG. With respect to cooking yield, performance of fresh AVG at 2.5% level in meat system was found to be similar with that of control. Cooking yield is the most practical test to predict the influence of non-meat ingredients and other factors, on behaviour of products during processing. Non-meat ingredients, such as macromolecular hydrocolloids, starches, and fibres, are known to have water binding properties (Pietrasik and Janz, 2010).

Table 2. Effect of *Aloe vera* gel addition on the texture profile analysis of goat meat nuggets

Parameters	Control nuggets	2.5 AVG nuggets	5 AVG nuggets
Hardness (N/cm^2)	70.77±1.15^a	66.47±1.17^{ab}	62.28±2.28^b
Fracturability (N)	38.22±1.61^a	35.55±2.37^a	24.36±1.23^b
Adhesiveness (Ns)	–0.01±0.01^a	–0.05±0.01^{ab}	–0.07±0.02^b
Springiness (cm)	0.78±0.02^a	0.70±0.02^b	0.66±0.02^b
Cohesiveness (ratio)	0.28±0.01	0.27±0.01	0.28±0.01
Gumminess (N/cm^2)	20.06±0.64^a	18.94±0.90^{ab}	16.80±1.06^b
Chewiness (N/cm)	15.60±0.60^a	11.78±0.88^b	12.51±0.94^b
Shear force (N/cm^2)	7.63±0.92	6.03±0.62	5.89±0.40
Work of shear (Ns)	4.08±0.57	3.19±0.44	3.41±0.23

AVG, *Aloe vera* gel.
Control nuggets, goat meat nuggets without AVG; 2.5 AVG nuggets, goat meat nuggets with 2.5% AVG; 5 AVG nuggets, goat meat nuggets with 5% AVG; (n = 18).
^{ab} Means bearing different superscripts in a row differ significantly ($p<0.05$).

Texture profile analysis

Texture profile analysis revealed that goat meat nuggets with AVG were comparatively softer and had less hardness, gumminess and chewiness and shear force values with respect to control nuggets (Table 2). Das et al. (2008a) reported that addition of hydrated full-fat soy paste markedly decreased the hardness of goat meat nuggets. The soft texture of fresh gel and higher moisture content might be a contributing factor to the lower hardness in nuggets containing AVG. Products hardness decrease with increase in moisture content (Verma et al., 1984). Significantly lower springiness in nuggets with AVG could be due to replacement of lean with AVG, hence loss of elasticity. Soft texture of gel significantly affected the chewiness and gumminess of nuggets containing AVG. Verma et al. (1984) found that sausages containing chickpea flour were softer in texture with increasing levels. Nuggets with gel had lower shear force and work of shearing values than control indicating their softer texture and this was also reflected in texture scores by the sensory panelists. Similarly, a decline in shear force value with lower lean meat content was reported by Das et al. (2006). Soltanizadeh and Ghiasi-Esfahani (2015) proposed that myofibrillar proteins and *Aloe vera* may compete for adsorption of water needed for

Table 3. Effect of *Aloe vera* gel addition on the fatty acid profile (% of total fatty acid) of goat meat nuggets

Fatty acids	Control nuggets	2.5 AVG nuggets	5 AVG nuggets
(C14:0)	1.49±0.07	1.05±0.20	1.37±0.23
(C16:0)	24.73±0.95	25.38±1.31	22.16±1.01
(C18:0)	6.66±0.34^a	5.72±0.34^{ab}	4.62±0.43^b
(C18:1)	54.00±2.21	56.78±3.17	61.54±2.47
(C18:2)	0.45±0.07	0.51±0.07	0.48±0.09
(C20:1)	7.80±0.59	8.25±0.71	8.08±0.47
(C20:2)	0.11±0.01	0.12±0.01	0.10±0.03
(C22:0)	0.23±0.04	0.23±0.02	0.27±0.03
(C20:3)	0.68±0.05	1.03±0.19	0.88±0.16
(C20:4)	3.96±0.50	3.09±0.52	3.76±0.63
(C24:0)	0.18±0.02	0.24±0.02	0.19±0.03
(C20:5)	0.73±0.09	0.56±0.24	0.85±0.32
% SFA	33.34±1.15^a	32.15±1.89^{ab}	27.93±1.36^b
% MUFA	53.00±1.15^b	54.59±2.21^{ab}	58.54±1.53^a
% PUFA	5.97±0.56	5.34±0.54	5.89±0.87
SFA/MUFA	0.63±0.03^a	0.60±0.06a^b	0.48±0.04^b
SFA/PUFA	5.86±0.64	6.16±0.31	5.26±0.74
PUFA/SFA	0.18±0.02	0.16±0.01	0.22±0.04

AVG, *Aloe vera* gel; SFA, saturated fatty acids; PUFA, polyunsaturated fatty acids; MUFA, mono-unsaturated fatty acids.
Control nuggets, goat meat nuggets without AVG; 2.5 AVG nuggets, goat meat nuggets with 2.5% AVG; 5 AVG nuggets, goat meat nuggets with 5% AVG; (n = 6).
^{ab} Means bearing different superscripts in a row differ significantly ($p<0.05$).

gel formation; hence, this competition interferes with the gel structure and formation of the gel matrix.

Fatty acid profile

Fatty acid profile showed that incorporation of AVG in goat meat nuggets affected the proportion of the individual as well as group of fatty acids (Table 3). The proportion C18:0 was significantly decreased in the products with 5% AVG. There was decreasing trends in the proportion of saturated fatty acids in the products with AVG while percent monounsaturated fatty acid showed the reverse trends.

Sensory evaluation

As observed from sensory evaluation, AVG significantly affected flavour and texture scores at 5% level which could have resulted in lower product's overall acceptability in comparison to control nuggets (Table 4). The control product and the nuggets containing 2.5% AVG were equally acceptable to the panel members. The sensory panelists detected a slightly bitter taste in the nuggets containing 5% AVG. Soltanizadeh and Ghiasi-Esfahani (2015) found the similar results when increasing concentration of *Aloe vera* was used in low meat beef burgers. They also reported that the overall acceptability scores of the beef burgers followed the trends of flavour acceptability scores, reflecting the major influence of flavour on overall acceptance. Aroma and flavour are probably the most important attributes that influence the sensory properties of comminuted meat products extended with non-meat protein additives (Das et al., 2008a). The adverse effect on flavour score could be due to presence of aloin with bitter taste in AVG (Tumlinson, 1985) while use of higher concentration makes the bitter taste more recognizable (Soltanizadeh and Ghiasi-Esfahani, 2015). Texture scores decreased significantly ($p<0.05$) at 5% level of AVG, which could be due to high moisture content in the product as well as possible interference in the formation of three-dimensional protein matrix in the meat batter. In this study, results of texture score were highly correlated with instrumental texture analysis (shear force). From sensory evaluation point of view, 2.5% AVG in the meat product was found optimum having no adverse impact on the sensory quality.

Table 4. Effect of *Aloe vera* gel addition on the sensory characteristics of goat meat nuggets

Parameters	Control nuggets	2.5 AVG nuggets	5 AVG nuggets
Appearance	6.90±0.09	6.89±0.08	6.78±0.08
Flavour	7.08±0.17[a]	6.93±0.10[a]	6.69±0.11[b]
Texture	7.21±0.14[a]	6.84±0.14[ab]	6.73±0.16[b]
Juiciness	7.04±0.10	7.12±0.08	7.19±0.07
Overall acceptability	7.25±0.10[a]	7.27±0.08[a]	6.63±0.14[b]

AVG, *Aloe vera* gel.
Control nuggets, goat meat nuggets without AVG; 2.5 AVG nuggets, goat meat nuggets with 2.5% AVG; 5 AVG nuggets, goat meat nuggets with 5% AVG; (n = 45).
[ab] Means bearing different superscripts in a row differ significantly ($p<0.05$).

Thiobarbituric acid reactive substances number and microbiological quality of goat meat nuggets

There are number of reports which claim that *Aloe vera* extract possesses good antioxidant activity, thus its efficacy in retarding lipid peroxidation of cooked goat meat nuggets was examined. Effect of AVG on TBARS number in cooked goat meat nuggets is shown in Figure 1. Goat meat nuggets with AVG had lower TBRAS number when compared with control product throughout the storage period. During the storage period, TBARS number increased significantly ($p<0.05$) in the control as well as treated nuggets. Lipid oxidation proceeded in the control nuggets and reached 0.75 mg malonaldehyde per kg sample during 9 day storage period. A general trend of increase in TBARS number during refrigerated storage of meat and meat products has been reported by many workers (Rajkumar et al., 2004; Verma et al., 2013; Gadekar et al., 2014). The increase in TBARS number in nuggets with AVG was very slow and remained lowest (0.66 mg malonaldehyde per kg sample) up to 9 days. Soltanizadeh and Ghiasi-Esfahani (2015) observed similar changes in the malonaldehyde content in beef burgers containing 3% and 5% *Aloe vera* powder during the 7 days of storage. Due to the presence of the antioxidant polyphenols, indoles, and alkaloids, the *Aloe vera* leaf gel shows strong antioxidant capacity (Nejatzadeh-Barandozi, 2013). The AVG extract had a strong antioxidant activity (Saritha et al., 2010) even equal or superior than synthetic antioxidants (Hu et al., 2005).

Microbial growth study revealed that incorporation of AVG in goat meat nuggets was effective in controlling the microbial counts throughout the 9 days of storage period. Nuggets with AVG had lower microbial counts

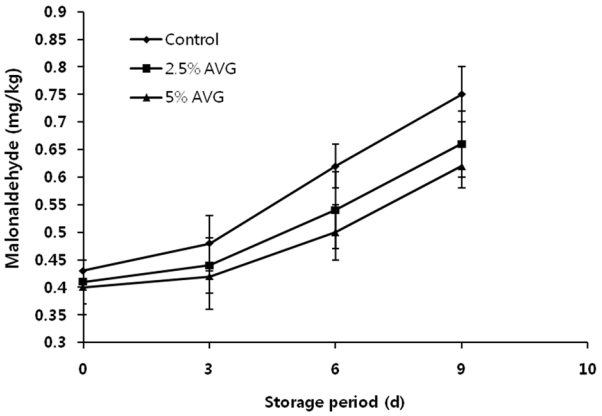

Figure 1. Lipid oxidation of goat meat nuggets containing different concentrations of *Aloe vera* gel (AVG) during refrigerated storage.

(supplementary data) than that of the control throughout the storage period. This could be due to antimicrobial properties and acidic pH of AVG. Saritha et al. (2010) observed that gel extract showed strong antibacterial activity against common pathogenic bacteria and efficacies was comparable with common antibiotics. Valverde et al. (2005) reported that antimicrobial and antifungal, as well as antioxidant effects of AVG could be involved in the action of the gel on maintaining the quality and safety of table grapes.

CONCLUSION

The results of present study suggest that the goat meat nuggets with 2.5% AVG performed similar to the control nuggets. Incorporation of AVG is positively associated with the many of the quality characteristics of meat product. The AVG in goat meat nuggets was also found to retard lipid peroxidation and microbial growth in the product during refrigerated storage. Thus incorporation of AVG, which is endowed with numerous nutritional and health values, in the emulsion based goat meat nuggets would definitely enrich the functional value of the products.

CONFLICT OF INTEREST

We certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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