Effect of packaging methods and crude aloe vera gel (*Aloe vera barbadensis* miller) on the storage quality of enrobed goat meat bites

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Abstract The storage stability of enrobed goat meat bites (EGMB) incorporated with 3 % crude aloe vera (AV) gel was evaluated under aerobic (T-1; unenrobed control product, T-2; enrobed AV treated product) and modified atmospheric packaging (MAP, 50:50, CO₂ and N₂) (T-3; unenrobed control product, T-4; enrobed AV treated product) at 4±1 °C for 42 days on the basis of physico-chemical, microbiological and sensory attributes. The pH value was higher, whereas water activity (*a_w*) was lower in enrobed and MAP product. Thiobarbituric acid reacting substances (TBARS) and free fatty acid (FFA) values were significantly (*P*<0.05) lower in MAP packaged (T-3) and AV treated products (T-2 and T-4) products than aerobic packaged (T-1), however it followed an increasing trend in all the products throughout storage. Instrumental colour and textural profile attributes were better maintained in MAP products than others. The sensory panellists graded T-4 ‘good to very good’ even on Day 42, whereas T-1 was acceptable only up to 28 days. Standard Plate Count (SPC) was significantly (*P*<0.05) lower in MAP products than aerobic packaged products. Results concluded that EGMB treated with AV gel can be successfully stored more than 42 days under MAP conditions without affecting its physico-chemical, textural, microbiological and sensory attributes.

Keywords Goat meat bites · Aerobic and modified atmospheric packaging · Storage quality

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Packaging is a scientific and techno-economical tool for containing food products and to maintain its storage quality. The type and nature of product viz. fresh, cured, smoked, cooked meat product directs the type of packaging materials and methods to be used (Sahoo and Anjaneyulu 1995). Packaging of meat is carried out to avoid contamination, permit some enzymatic activity to improve tenderness, delay spoilage and sometimes to ensure an oxymyoglobin or cherry red colour in red meats at retail or consumer level (Brody 1997). Lipids are oxidised and form secondary lipid oxidation products, leading to rancid off-flavour in the meat or meat product. The rancid aromas have often very low threshold values and are easily detected by the consumers (Campo et al. 2006).

Carbon dioxide is commonly used in retail packaging to reduce microbiological growth and Gram-ve bacteria are more sensitive to CO₂ (Blickstad and Molin 1983). Carbonyl formation is a common indicator of the oxidative stability of proteins in biological systems (Headlam and Davies 2002) and a marker of the oxidative stability in meat products (Stadtman 1990; Ganhao et al. 2010; Lund et al. 2007; Salminen et al. 2006). For pre-cooked meat and poultry products, oxygen is usually not used in MAP. Patsias and co-workers (2006) observed that MAP was more effective than aerobic packaging for extending the shelf life of pre-cooked chicken meat. In this study, the growth of spoilage bacteria on chicken breast fillets (packaged in MAP with 60–90 % CO₂) was inhibited for 1 week and oxidative stability was greatest in comparison to aerobic packaging. Skandamis and Nychas (2001) reported that addition of oregano essential oil (0.5–1.0 %) to minced beef before packaging in MAP reduced the total plate count by 2–3 log and extended the product shelf life by 12 days during storage at 5 °C in comparison to 5 days in aerobic packaging. Modified atmosphere containing either 25 or 50 % CO₂ and balance N₂ resulted in the best microbial control in irradiated pork held at 4 °C as compared to an

unirradiated MAP control (Irene and Margaret 2007). Karabagias et al. (2011) observed the effect of thyme (TEO) and oregano (OEO) essential oils as well as modified atmosphere packaging (MAP) in extending the shelf life of fresh lamb meat stored at 4 °C and found that shelf life of lamb meat was 7 days for air packaged samples, 9–10 days for samples containing 0.1 % of TEO and 21–22 days for MAP packaged samples containing 0.1 % TEO. Hasapidou and Savvaidis (2011) studied the effects of modified atmosphere packaging (30 % CO₂, 70 % N₂), EDTA and oregano oil on the quality of chicken liver meat and concluded that the shelf-life of chicken liver meat may substantially be extended (by almost 3 times the usual product's shelf-life using a natural antimicrobial combination (EDTA, oregano oil and MAP). Viuda-Martos et al. (2010) studied the effect of orange dietary fibre, oregano essential oil and vacuum, air and modified atmosphere (80 % N₂ and 20 % CO₂) packaging conditions on shelf-life of bologna sausages and found the MAP packaged product on 24th day of storage as fresh as on 1st day and limited rise in TBARS value of the MAP packaged product.

Enrobing reduces weight loss as it acts as sealant and also prevents high oil uptake during frying of the product (Cunningham 1989) and thus provides processors with added value at low cost (Jessup 1981). Natural antioxidants limit the lipid oxidation and enhance the shelf life.

In the event of limited research available on the aspect of the storage quality of MAP packaged enrobed products, the present study was conducted with an objective to evaluate life of enrobed goat meat bites (EGMB) incorporated with crude aloe vera gel (*Aloe vera barbadensis* Miller) under aerobic and modified atmospheric packaging conditions at 4±1 °C.

Materials and methods

Materials

Three castrated bucks of Beetle breed (12–14 months age and 25–30 kg weight) were selected from Institutional Livestock farm GADVASU and were humanely slaughtered in the experimental slaughter house with a consideration of animal welfare. The carcasses were fabricated, chilled at 4±1 °C for 24 h and then deboned manually. The carcass was trimmed for excessive connective tissue, fascia and fat and packaged in low density polyethylene film (LDPE) bags and stored at -18±1 °C. The frozen lean chevon was cut into cubes of size 1.5 cm×1.5 cm×1.5 cm. Aloe vera plant leaves were collected from GADVASU Campus (Ludhiana, Punjab, India) and the crude gel was taken out with plastic spatula after opening the leaves with stainless steel knife. LDPE bags (140 gauge) and double layered laminated plastic pouches (Polyester/Polyethylene 100/100 µ) were used for aerobic and modified atmosphere packaging (MAP) of the product, respectively. All the required chemicals in the

study were of analytical grade, readymade cultures media and standards were procured from reputed firms like Sisco Research Laboratories, Hi-Media and Sigma-Aldrich, respectively.

Preparation of goat meat bites

The chunks were thawed overnight at 4±1 °C and dipped in 1:1 tenderizing solution (0.25 % papain and 0.15 M CaCl₂) for 24 h at 4±1 °C (Biswas et al. 2009). Chunks were seasoned for 1 h in a formulation standardized in the laboratory (Jairath et al. 2012). Seasoned chunks were preheated in oven at 175 °C for 40 min. with intermittent turning. The batter mix was prepared (Table 1) and oven cooked bites were coated, breaded and subsequently deep fat fried at 175 °C for 3 min. in deep fat fryer (Black and Decker, China). Goat meat bites (GMB) without enrobing were used as control. A total number of four treatments was prepared viz. T-1 (unenrobed control product aerobic packaged), T-2 (enrobed and AV treated, aerobic packaged), T-3 (unenrobed control MAP), T-4 (enrobed AV treated MAP). MAP was carried out with a combination of 50 % N₂+50 % CO₂ using Roschermatic vacuum packaging machine, Type 19/S/CL, with three gas mixers (Dansensor Germany). The packaging bags were washed with hydrogen peroxide and subsequently sterilized in the laminar flow (Model: RH-58-03; Rescholar equipments, Ambala) with ultra-violet radiation for 30 min. All the packaged samples were stored at refrigeration temperature (4±1 °C) in dark and were analysed at an interval of 7 days. The samples were analyzed for physico-chemical parameters (pH, water activity, TBARS, FFA), colour and texture profiles, microbial qualities (SPC, total coliform count, *Staphylococci* count and yeast and mould count and sensory attributes.

Physico-chemical parameters

pH and water activity (a_w) The pH and a_w of sample ($n=6$) was determined by Trout et al. (1992) using pH meter (FE-20-1-KIT, Mettler-Toledo India Pvt. Ltd., Mumbai) and hand

Table 1 Formulation of batter mix for preparation of enrobed goat meat bites

Ingredients	Percent (w/w)
Bengal gram flour	30.40
Added water (v/w)	38.60
Liquid Egg White	25.00
SMP	2.40
Salt	1.40
Sugar	0.20
Spice mix	1.00
Deggi mirch (Red pepper)	1.00
Crude aloe vera gel	3.00

held potable digital water activity meter (Rotronic HYGRO Palm AW1 Set/40 USA), respectively.

Thiobarbituric acid reacting substances (TBARS) and free fatty acids (FFA) value TBARS and FFA values were determined by methods described by Witte et al. (1970) and Koniecko (1979) in mg per kg malonaldehyde and percentage, respectively.

Colour profile

Colour profile was measured using Lovibond Tintometer (Lovibond RT-300, Reflectance Tintometer, United Kingdom) set at 2° of cool white light (D_{65}) and known as L^* , a^* , and b^* values. L^* denotes (brightness 100) or lightness (0), a^* (+redness/- greenness), b^* (+yellowness/-blueness) values were recorded on bites kept in a group in the petridish.

Texture profile analysis

Texture profile analysis (TPA) was conducted using Texture Analyzer (TMS-PRO, Food Technology Corporation, USA) as described by Bourne (1978). Sample size of 1 cm×1 cm×1 cm was subjected to pre-test speed (30 mm/s), post test speed (100 mm/s) and test speed (100 mm/s) to a double compression cycle with a load cell of 2,500 N. A compression platform of 25 mm was used as a probe. Parameters like hardness, springiness, stringiness, cohesiveness, chewiness, gumminess and resilience were calculated automatically by the preloaded Texture Pro software in the equipment from the force-time plot. Five readings were recorded for each sample.

Assay for microbiological quality

Standard Plate Counts (SPC), *Staphylococci* counts, total coliforms counts and Yeast and mold counts of the samples were enumerated following the methods as described by American Public Health Association (APHA 1992) by using Plate Count Agar, Baird Parker Agar, Violet Red Bile Glucose Agar and Potato Dextrose Agar, respectively (Hi-Media Laboratories Pvt. Ltd., Mumbai). The average number of colonies were multiplied by the reciprocal of the dilution and expressed as log₁₀ cfu/g.

Sensory evaluation

A panel of six-member experienced judges consisting of faculty members and postgraduate students of department of Livestock Products Technology, GADVASU evaluated the samples for the sensory attributes of colour and appearance, texture, flavour, crispiness, tenderness, juiciness and overall acceptability using 8-point descriptive scale (Keeton 1983), where 8=excellent and 1=extremely poor. Two training

sessions of the sensory panellists were conducted to detail them about the product characteristics and sensory performance. The test samples were presented to the panellists after assigning the suitable codes. The samples were warmed in a microwave oven for 20s before being served to the sensory panellists. The water was served for rinsing the mouth before another sample was evaluated.

Statistical analysis

Data was analyzed statistically on 'SPSS-16.0' (SPSS Inc., Chicago, IL USA) software package as per standard methods (Snedecor and Cochran 1994). Duplicate samples were drawn for each parameter except texture ($n=5$) and colour profile ($n=6$) and the whole set of experiment was repeated three times to have total number of observations $N=6$ for all parameters and $N=15$ for colour and $N=18$ for texture. Sensory evaluation was performed by a panel of six member judges. The data was statistically analyzed by two way analysis of variance (ANOVA) at 5 % level ($p<0.05$) and evaluated with Duncan's Multiple Range Test.

Results and discussion

Physico-chemical quality

Results in Table 2 showed that pH was significantly ($p<0.05$) higher in treated products (T-2 and T-4) than control (T-1 and T-3) in both the packaging groups. The higher pH of the developed product than control is attributed to the higher pH of batter mix (6.39 ± 0.03) and formulation of batter mix, both of which in turn resulted in improved buffering capacity of the product (Yetim et al. 1992). Similar findings were observed by Biswas et al. (2004) in enrobed pork patties. The product pH in both the groups varied significantly ($p<0.05$) with the storage days. It decreased significantly ($p<0.05$) on the 7th day however, thereafter it increased in following storage, irrespective of the type of product and type of packaging methods. Jay et al. (1962) suggested that the metabolic activity of the bacteria convert sugar into acids which lowers the pH and Aksu et al. (2005) and Karabagias et al. (2011) suggested rise in pH due to deamination of proteins. The critical analysis of pH results revealed that the increase in the pH of MAP packaged products was at slower rate, which might be due to buffering by carbonic acid produced due to the influx of CO₂ gas in the package (Ashie et al. 1996).

The water activity level was significantly ($p<0.05$) higher in control groups (T-1 and T-3) than treated products (T-2 and T-4) in both the packaging groups. It was further observed that a_w value was significantly ($p<0.05$) higher in MAP packaged products (T-3 and T-4) than aerobic packaged products (T-1

Table 2 Physico-chemical properties of EGMB stored at refrigeration temperature ($4\pm 1\text{ }^{\circ}\text{C}$) under aerobic and modified atmosphere packaging (MAP) conditions

Treatments/Days	Day 0	Day 7	Day 14	Day 21	Day 28	Day 35	Day 42
Product pH							
T-1	5.64 $\pm$ 0.05 ^{Ac}	5.20 $\pm$ 0.06 ^{Aa}	5.41 $\pm$ 0.06 ^b	5.71 $\pm$ 0.06 ^{Ac}	5.72 $\pm$ 0.06 ^{Ac}	NP	NP
T-2	5.91 $\pm$ 0.08 ^{Bbc}	5.42 $\pm$ 0.08 ^{Ba}	5.77 $\pm$ 0.09 ^b	5.95 $\pm$ 0.09 ^{Bbc}	5.99 $\pm$ 0.08 ^{Bbc}	6.11 $\pm$ 0.08 ^c	NP
T-3	5.69 $\pm$ 0.10 ^{Ab}	5.18 $\pm$ 0.10 ^{Aa}	5.50 $\pm$ 0.10 ^b	5.83 $\pm$ 0.10 ^{ABbc}	5.85 $\pm$ 0.10 ^{ABbc}	5.90 $\pm$ 0.10 ^{bc}	6.07 $\pm$ 0.10 ^{Ac}
T-4	5.85 $\pm$ 0.09 ^{Bb}	5.49 $\pm$ 0.09 ^{Ba}	5.78 $\pm$ 0.09 ^b	5.90 $\pm$ 0.09 ^{Bbc}	5.93 $\pm$ 0.09 ^{ABbc}	6.16 $\pm$ 0.09 ^{cd}	6.34 $\pm$ 0.09 ^{Bd}
Water activity							
T-1	0.960 $\pm$ 0.004 ^{Bc}	0.953 $\pm$ 0.003 ^{Bb}	0.948 $\pm$ 0.003 ^{BCb}	0.946 $\pm$ 0.002 ^{Cab}	0.940 $\pm$ 0.002 ^{Ba}	NP	NP
T-2	0.942 $\pm$ 0.001 ^{Ad}	0.939 $\pm$ 0.002 ^{Acd}	0.936 $\pm$ 0.002 ^{Abc}	0.932 $\pm$ 0.002 ^{Aab}	0.929 $\pm$ 0.002 ^{Aa}	0.927 $\pm$ 0.002 ^{Aa}	NP
T-3	0.962 $\pm$ 0.001 ^{Bd}	0.958 $\pm$ 0.001 ^{Bcd}	0.954 $\pm$ 0.002 ^{Cbc}	0.953 $\pm$ 0.001 ^{Db}	0.950 $\pm$ 0.001 ^{Cb}	0.945 $\pm$ 0.002 ^{Ca}	0.942 $\pm$ 0.001 ^{Ba}
T-4	0.943 $\pm$ 0.002 ^{Ac}	0.942 $\pm$ 0.001 ^{Ac}	0.942 $\pm$ 0.002 ^{ABc}	0.939 $\pm$ 0.001 ^{Bbc}	0.937 $\pm$ 0.001 ^{Bab}	0.936 $\pm$ 0.001 ^{Bab}	0.933 $\pm$ 0.001 ^{Aa}
FFA (%)							
T-1	0.120 $\pm$ 0.001 ^{Ba}	0.217 $\pm$ 0.001 ^{Db}	0.263 $\pm$ 0.002 ^{Dc}	0.308 $\pm$ 0.002 ^{Dd}	0.386 $\pm$ 0.002 ^{Ce}	NP	NP
T-2	0.113 $\pm$ 0.001 ^{Aa}	0.154 $\pm$ 0.001 ^{Bb}	0.168 $\pm$ 0.002 ^{Bc}	0.186 $\pm$ 0.002 ^{Bd}	0.223 $\pm$ 0.002 ^{Be}	0.240 $\pm$ 0.001 ^{Bf}	NP
T-3	0.118 $\pm$ 0.001 ^{Ba}	0.168 $\pm$ 0.001 ^{Cb}	0.197 $\pm$ 0.002 ^{Cc}	0.214 $\pm$ 0.002 ^{Cd}	0.225 $\pm$ 0.002 ^{Be}	0.238 $\pm$ 0.001 ^{Bf}	0.244 $\pm$ 0.001 ^{Bg}
T-4	0.110 $\pm$ 0.001 ^{Aa}	0.118 $\pm$ 0.001 ^{Ab}	0.125 $\pm$ 0.002 ^{Ac}	0.131 $\pm$ 0.002 ^{Ad}	0.142 $\pm$ 0.002 ^{Ae}	0.153 $\pm$ 0.001 ^{Af}	0.165 $\pm$ 0.001 ^{Ag}

$n=6$; NP=not performed; T-1=Aerobic control, T-2=Aerobic treated, T-3=MAP control, T-4=MAP treated

*Mean $\pm$ S.E. with different superscripts row wise (small alphabets) and column wise (capital alphabets) differ significantly ($p<0.05$)

and T-2) and this trend followed throughout the storage period. It is attributed to the packaging material, water impermeable films/laminates (polyester and propylene 100/100 μ) used in MAP, which restricts the loss of moisture in the product during storage. In general, a_w followed a declining trend in all the products during storage, but the decrease of a_w was comparatively lower in MAP packaged products than aerobic packaged products. Kong et al. (2010) also reported higher water activity at 0 week in jerky meat product which decreased smoothly for 24 weeks of storage under MAP.

TBARS values (Fig. 1) followed an increasing trend throughout the storage period irrespective of packaging materials and methods, as well as presence or absence of natural antioxidants (AV gel) in the formulation. TBARS value was significantly ($p<0.05$) higher in treated products (T-2 and T-4) in both the package groups than their respective control products (T-1 and T-3) on day 0. It might be due to additional fat pick up by enrobing material during frying in enrobed products. TBARS values were comparable in all the treatments (T-1 and T-4) on 7th day thereafter, it was lower in the developed product than their respective control on further storage. Additionally, TBARS value was recorded lower for MAP products than aerobic packaged products, irrespective of type of formulation. TBARS values were significantly ($p<0.05$) lower in aloe vera treated products than other products, irrespective of storage days and packaging methods. It might be due to the antioxidant effect of aloe vera gel (Saritha et al. 2010). TBARS values measured highest for aerobic packaged control (T-1), more than the threshold limit of 1.0 (1.123 $\pm$ 0.03) on 35th day of the storage. There was a

detectable off odour with TBARS values more than 1.0 (Melton 1983) which was also confirmed by the sensory panellists (Table 6).

Free fatty acids, the products of enzymatic or microbiological degradation of lipids, are the indicator of fat stability during storage. The increasing trend of FFA values was found in accordance to the TBARS values. These were lower in MAP packaged products than aerobic packaged products throughout the storage period. It could be due to the absence of oxygen in MAP package required for lipid oxidation. The results are in agreement with Panda et al. (1993) in deep fat fried quail, Kanatt et al. (1998) in chicken meat during low temperature storage.

Colour profile

Lovibond tintometer colour values (L^* , a^* and b^*) were significantly ($p<0.05$) influenced by the packaging methods and storage period (Table 3). The colour attributes were better maintained in MAP products than control. It might be due to packaging materials, infusion of gas mixtures in the product package (CO_2 and N_2) and presence of natural antioxidant (3 % aloe vera gel), which prevents the enzymatic and non enzymatic browning to a greater extent (Tosun and Aceites 2004). It also delays the lipid oxidation process and moisture loss, thereby minimal discolouration of the product. L^* , a^* and b^* values were significantly ($p<0.05$) higher in treated products than their respective control in both the package groups.

Fig 1 Variations in TBARS values (mg malonaldehyde/Kg) of EGMB during refrigerated aerobic and MAP storage. T-1=unenrobed control product aerobic packaged), T-2=enrobed AV treated, aerobic packaged), T-3=unenrobed control MAP), T-4=enrobed AV treated MAP)

Redness values (a^*) were comparable in all the treated products on day 0, irrespective of type of formulation, treatment and packaging. The values did not follow the linear trend throughout the storage, but the values were significantly ($p < 0.05$) lower on the last day of storage than their respective values on day 0. The redness value was significantly ($p < 0.05$) higher in treated product packaged in MAP condition (T-4) on

the last day of storage (42nd day). This can be attributed to the better maintenance of the quality parameters due to lower gas transmission rate and water vapour transmission rate in MAP packaged product.

Yellowness (b^*) value was significantly ($p < 0.05$) higher in the treated products than control and followed a decreasing trend in all the products throughout the storage period in both

Table 3 Change in Lovibond tintometer colour values of EGMB stored at refrigeration temperature (4 ± 1 °C) under aerobic and modified atmosphere packaging (MAP) conditions (Mean $\pm$ S.E.)

Treatments/Days	Day 0	Day 7	Day 14	Day 21	Day 28	Day 35	Day 42
Lightness (L^* value)							
T-1	41.03 $\pm$ 0.44 ^{Ad}	39.01 $\pm$ 0.35 ^{Ac}	35.47 $\pm$ 0.36 ^{Ab}	34.30 $\pm$ 0.46 ^{Ab}	30.36 $\pm$ 0.51 ^{Aa}	NP	NP
T-2	46.92 $\pm$ 0.40 ^{Bf}	44.91 $\pm$ 0.35 ^{Be}	43.19 $\pm$ 0.36 ^{Cd}	39.77 $\pm$ 0.41 ^{Cc}	37.09 $\pm$ 0.51 ^{Cb}	33.42 $\pm$ 0.47 ^{Ba}	NP
T-3	41.22 $\pm$ 0.44 ^{Af}	38.76 $\pm$ 0.35 ^{Ac}	37.55 $\pm$ 0.36 ^{Bde}	36.85 $\pm$ 0.46 ^{Bd}	34.18 $\pm$ 0.51 ^{Bc}	31.63 $\pm$ 0.47 ^{Ab}	30.11 $\pm$ 0.43 ^{Aa}
T-4	46.82 $\pm$ 0.40 ^{Bd}	46.85 $\pm$ 0.35 ^{Bd}	44.05 $\pm$ 0.36 ^{Cc}	43.78 $\pm$ 0.46 ^{Dc}	42.08 $\pm$ 0.18 ^{Db}	39.64 $\pm$ 0.32 ^{Ca}	38.54 $\pm$ 0.14 ^{Ba}
Redness (a^* value)							
T-1	13.27 $\pm$ 0.37 ^{Ad}	11.67 $\pm$ 0.30 ^{7Bc}	10.43 $\pm$ 0.30 ^{Ab}	10.18 $\pm$ 0.30 ^{Aa}	11.51 $\pm$ 0.30 ^{Bc}	NP	NP
T-2	12.67 $\pm$ 0.60 ^{Ac}	9.45 $\pm$ 0.60 ^{Aab}	8.33 $\pm$ 0.60 ^{Aa}	7.67 $\pm$ 0.60 ^{Aa}	8.97 $\pm$ 0.60 ^{Aab}	10.43 $\pm$ 0.60 ^b	NP
T-3	12.66 $\pm$ 0.40 ^{Ad}	11.45 $\pm$ 0.40 ^{Bcd}	11.90 $\pm$ 0.40 ^{Bcd}	10.98 $\pm$ 0.40 ^{Bbc}	11.03 $\pm$ 0.40 ^{Bbc}	9.83 $\pm$ 0.40 ^b	8.07 $\pm$ 0.40 ^{Aa}
T-4	12.21 $\pm$ 0.75 ^{Ab}	11.88 $\pm$ 0.75 ^{Bb}	10.97 $\pm$ 0.75 ^{Bab}	10.08 $\pm$ 0.75 ^{Bab}	11.87 $\pm$ 0.75 ^{Bb}	9.34 $\pm$ 0.75 ^a	11.04 $\pm$ 0.75 ^{Ba}
Yellowness (b^* value)							
T-1	16.70 $\pm$ 0.61 ^{Ab}	14.88 $\pm$ 0.61 ^{Ab}	12.71 $\pm$ 0.61 ^{Aa}	12.86 $\pm$ 0.61 ^{Aa}	14.95 $\pm$ 0.61 ^{Ab}	NP	NP
T-2	23.26 $\pm$ 0.69 ^{Bc}	21.72 $\pm$ 0.69 ^{Cc}	21.43 $\pm$ 0.69 ^{Bc}	17.96 $\pm$ 0.69 ^{Bb}	19.17 $\pm$ 0.69 ^{Bb}	12.35 $\pm$ 0.69 ^{Ba}	NP
T-3	16.62 $\pm$ 0.66 ^{Ac}	13.20 $\pm$ 0.66 ^{Ab}	14.10 $\pm$ 0.66 ^{Ab}	13.20 $\pm$ 0.66 ^{Ab}	13.4 $\pm$ 0.66 ^{Ab}	11.09 $\pm$ 0.66 ^{Aa}	10.03 $\pm$ 0.66 ^{Aa}
T-4	23.51 $\pm$ 0.85 ^{Bb}	24.15 $\pm$ 0.85 ^{Db}	23.64 $\pm$ 0.85 ^{Cb}	21.95 $\pm$ 0.85 ^{Cab}	23.75 $\pm$ 0.85 ^{Cb}	20.34 $\pm$ 0.85 ^{Ca}	21.49 $\pm$ 0.85 ^{Ba}

$n=15$; NP=not performed; C=Aerobic control, T-1=Aerobic treated, T-3=MAP control, T-4=MAP treated

*Mean $\pm$ S.E. with different superscripts row wise (small alphabets) and column wise (capital alphabets) differ significantly ($p < 0.05$)

the package groups. These observations are in consonance with the observations of various workers in different meat products (Jo et al. 2001 and Geograntelis et al. 2007).

Texture profile

Texture profile (Table 4) of EGMB during storage revealed that hardness was comparable in all the products, irrespective of type of formulation, treatment and packaging conditions on

day 0. However, it increased with the progress of storage period. It might be due to loss of moisture from the surface on longer storage, which in turn increases hardness of the product. It is directed by the water vapour transmission rate of the packaging material and enrobing of the product (Dragich and Krochta 2009).

Springiness, stringiness and cohesiveness did not vary with the treatments and the packaging conditions. However, the textural attributes followed a declining trend during storage,

Table 4 Texture profile of EGMB stored at refrigeration temperature ($4\pm 1^\circ\text{C}$) under aerobic and modified atmosphere packaging (MAP) conditions

Treatments/ Days	Day 0	Day 7	Day 14	Day 21	Day 28	Day 35	Day 42
Hardness (N)							
T-1	15.26 $\pm$ 0.43 ^{Aa}	28.22 $\pm$ 0.42 ^{Cb}	34.58 $\pm$ 0.34 ^{Dc}	38.29 $\pm$ 0.36 ^{Dd}	43.61 $\pm$ 0.46 ^{De}	NP	NP
T-2	15.44 $\pm$ 0.42 ^{Aa}	22.39 $\pm$ 0.41 ^{Bb}	25.91 $\pm$ 0.33 ^{Bc}	29.92 $\pm$ 0.37 ^{Bd}	35.39 $\pm$ 0.47 ^{Ce}	38.31 $\pm$ 0.35 ^{Cf}	NP
T-3	15.85 $\pm$ 0.41 ^{Aa}	23.02 $\pm$ 0.41 ^{Bb}	28.70 $\pm$ 0.33 ^{Cc}	33.20 $\pm$ 0.35 ^{Cd}	33.62 $\pm$ 0.47 ^{Bd}	36.93 $\pm$ 0.35 ^{Be}	40.83 $\pm$ 0.40 ^{Bf}
T-4	15.18 $\pm$ 0.43 ^{Aa}	18.36 $\pm$ 0.40 ^{Ab}	21.03 $\pm$ 0.34 ^{Ac}	23.95 $\pm$ 0.37 ^{Ad}	26.55 $\pm$ 0.44 ^{Ae}	27.50 $\pm$ 0.36 ^{Ae}	31.06 $\pm$ 0.39 ^{Af}
Springiness (mm)							
T-1	27.57 $\pm$ 1.73	27.29 $\pm$ 0.35	27.12 $\pm$ 0.66	28.08 $\pm$ 0.24	28.43 $\pm$ 0.12	NP	NP
T-2	26.20 $\pm$ 0.39	27.20 $\pm$ 0.35	28.09 $\pm$ 0.66	25.35 $\pm$ 0.24	28.38 $\pm$ 0.37	28.072 $\pm$ 0.53	NP
T-3	27.66 $\pm$ 0.25	27.80 $\pm$ 1.73	26.87 $\pm$ 0.34	27.60 $\pm$ 0.21	27.92 $\pm$ 0.13	28.33 $\pm$ 0.14	26.89 $\pm$ 0.37
T-4	27.38 $\pm$ 0.25	27.90 $\pm$ 0.35	28.82 $\pm$ 0.66	26.48 $\pm$ 0.93	27.95 $\pm$ 0.51	28.00 $\pm$ 0.93	27.96 $\pm$ 0.51
Stringiness (mm)							
T-1	24.99 $\pm$ 0.30 ^{ab}	23.72 $\pm$ 0.23 ^a	22.64 $\pm$ 1.01 ^{Aa}	28.17 $\pm$ 1.26 ^b	25.12 $\pm$ 0.78 ^{ab}	NP	NP
T-2	27.69 $\pm$ 1.14	26.65 $\pm$ 0.90	28.53 $\pm$ 0.87 ^B	26.45 $\pm$ 0.41	26.01 $\pm$ 0.69	25.85 $\pm$ 0.71	NP
T-3	26.17 $\pm$ 1.311 ^{ab}	23.77 $\pm$ 0.54 ^{ab}	21.93 $\pm$ 0.78 ^{Aa}	28.43 $\pm$ 1.10 ^b	26.86 $\pm$ 0.95 ^{ab}	25.63 $\pm$ 0.47 ^{ab}	24.49 $\pm$ 0.39 ^{ab}
T-4	26.82 $\pm$ 1.28 ^{ab}	25.94 $\pm$ 0.80 ^{ab}	28.84 $\pm$ 0.34 ^{Bb}	25.49 $\pm$ 1.06 ^{ab}	24.88 $\pm$ 1.62 ^a	24.27 $\pm$ 1.32 ^a	24.42 $\pm$ 0.71 ^a
Cohesiveness							
T-1	0.61 $\pm$ 0.01 ^c	0.59 $\pm$ 0.02 ^{bc}	0.57 $\pm$ 0.01 ^{ab}	0.56 $\pm$ 0.01 ^a	0.55 $\pm$ 0.01 ^a	NP	NP
T-2	0.61 $\pm$ 0.02 ^b	0.58 $\pm$ 0.01 ^{ab}	0.58 $\pm$ 0.01 ^{ab}	0.57 $\pm$ 0.01 ^{ab}	0.55 $\pm$ 0.01 ^a	0.53 $\pm$ 0.02 ^{Aa}	NP
T-3	0.60 $\pm$ 0.01 ^c	0.58 $\pm$ 0.02 ^{bc}	0.56 $\pm$ 0.01 ^{ab}	0.59 $\pm$ 0.02 ^{bc}	0.57 $\pm$ 0.01 ^{abc}	0.56 $\pm$ 0.01 ^{ABab}	0.53 $\pm$ 0.01 ^{Aa}
T-4	0.61 $\pm$ 0.01 ^b	0.60 $\pm$ 0.02 ^{ab}	0.59 $\pm$ 0.01 ^{ab}	0.57 $\pm$ 0.01 ^{ab}	0.58 $\pm$ 0.01 ^{ab}	0.57 $\pm$ 0.01 ^{Ba}	0.56 $\pm$ 0.01 ^{Ba}
Chewiness (J)							
T-1	389.58 $\pm$ 1.67 ^{Ba}	556.15 $\pm$ 3.15 ^{Bb}	499.72 $\pm$ 3.14 ^{Bb}	665.89 $\pm$ 1.32 ^{Bc}	710.10 $\pm$ 1.46 ^{Bc}	NP	NP
T-2	159.31 $\pm$ 0.64 ^{Aa}	221.07 $\pm$ 1.82 ^{Aa}	326.81 $\pm$ 1.73 ^{Ab}	369.60 $\pm$ 1.32 ^{Abc}	440.32 $\pm$ 2.94 ^{Acd}	480.45 $\pm$ 2.94 ^{Ad}	NP
T-3	427.29 $\pm$ 2.17 ^{Ba}	550.05 $\pm$ 1.14 ^{Bbc}	456.69 $\pm$ 2.18 ^{Bab}	649.34 $\pm$ 1.32 ^{Bc}	675.96 $\pm$ 1.59 ^{Bd}	690.56 $\pm$ 1.57 ^{Bd}	794.95 $\pm$ 3.20 ^{Be}
T-4	175.31 $\pm$ 0.94 ^{Aa}	228.05 $\pm$ 0.67 ^{Aab}	296.29 $\pm$ 2.93 ^{Abc}	315.81 $\pm$ 1.31 ^{Ac}	361.53 $\pm$ 1.19 ^{Acd}	420.52 $\pm$ 1.46 ^{Ad}	430.239 $\pm$ 3.90 ^{Adg}
Gumminess (N)							
T-1	13.85 $\pm$ 0.98 ^{Ba}	19.75 $\pm$ 0.38 ^{Bb}	19.11 $\pm$ 0.36 ^{Bc}	23.11 $\pm$ 1.46 ^{Bc}	29.93 $\pm$ 0.14 ^{Bd}	NP	NP
T-2	6.04 $\pm$ 0.98 ^{Aa}	8.22 $\pm$ 0.38 ^{Aab}	11.59 $\pm$ 0.64 ^{Abc}	14.70 $\pm$ 0.40 ^{Acd}	15.59 $\pm$ 0.64 ^{Ad}	22.15 $\pm$ 0.43 ^{Be}	NP
T-3	15.41 $\pm$ 0.98 ^{Ba}	19.69 $\pm$ 0.63 ^{Bb}	16.55 $\pm$ 0.28 ^{Bab}	22.41 $\pm$ 0.258 ^{Bbc}	31.26 $\pm$ 0.25 ^{Bc}	29.00 $\pm$ 0.14 ^{Cc}	29.09 $\pm$ 0.19 ^{Bc}
T-4	6.75 $\pm$ 1.12 ^{Aa}	8.76 $\pm$ 1.16 ^{Aab}	11.72 $\pm$ 1.12 ^{Abc}	11.91 $\pm$ 1.40 ^{Abc}	15.31 $\pm$ 0.36 ^{Acd}	15.70 $\pm$ 0.57 ^{Ad}	19.42 $\pm$ 0.39 ^{Ae}
Resilience							
T-1	0.59 $\pm$ 0.01 ^c	0.58 $\pm$ 0.01 ^{bc}	0.56 $\pm$ 0.01 ^{ab}	0.55 $\pm$ 0.01 ^{ab}	0.54 $\pm$ 0.01 ^a	NP	NP
T-2	0.59 $\pm$ 0.01 ^d	0.56 $\pm$ 0.01 ^c	0.55 $\pm$ 0.01 ^{bc}	0.54 $\pm$ 0.01 ^b	0.53 $\pm$ 0.01 ^{ab}	0.51 $\pm$ 0.01 ^a	NP
T-3	0.58 $\pm$ 0.01 ^d	0.57 $\pm$ 0.01 ^d	0.56 $\pm$ 0.01 ^{cd}	0.55 $\pm$ 0.01 ^{bc}	0.55 $\pm$ 0.01 ^{bc}	0.53 $\pm$ 0.01 ^{ab}	0.51 $\pm$ 0.01 ^a
T-4	0.58 $\pm$ 0.01 ^e	0.57 $\pm$ 0.01 ^{de}	0.56 $\pm$ 0.01 ^d	0.54 $\pm$ 0.01 ^c	0.53 $\pm$ 0.01 ^{bc}	0.52 $\pm$ 0.01 ^{ab}	0.51 $\pm$ 0.01 ^a

$n=18$; NP=not performed; C=Aerobic control, T-1=Aerobic treated, T-3=MAP control, T-4=MAP treated

*Mean $\pm$ S.E. with different superscripts row wise (small alphabets) and column wise (capital alphabets) ($p<0.05$)

especially in aerobic packaged product. Chewiness and gumminess values were significantly ($p<0.05$) lower in treated products than control in both the packaged groups. However, it followed an increasing trend during storage in both the groups. This might be due to the correlation of hardness with chewiness. Resilience was comparable amongst all the treatments, irrespective of type of packaging and followed a declining trend throughout the storage period.

Microbiological quality

Microbiological quality (Table 5) of meat bites was significantly ($p<0.05$) influenced by packaging conditions during refrigerated storage. SPC was significantly ($p<0.05$) lower in MAP packaged product than aerobic packaged product. SPC was lower than the threshold limit (5.33 log cfu/g) in the treated product on 35th day of the aerobic packaging and 42nd day of MAP storage. However, aerobic control (T-1) had higher microbial load than the threshold level. The slime formation and putrid odour reported by sensory panellists confirms the higher microbial load. The lower microbial load in MAP packed products could be due to the addition of 50 % CO₂ gas in the package, which acts on the lag phase of bacterial growth cycle and produces carbonic acid, which in turn inhibits the growth of bacteria (Ashie et al. 1996). The microbial load was 2 log cycles lower than in MAP packaged product as compared to aerobic packaged products, which confirm the bactericidal effect of CO₂ gas as stated by Blickstad and Molin (1983)

Staphylococci count and yeast and mould count were not detected up to 28th day in aerobic packaged developed product (T-2) and 21st day in aerobic packaged control (T-1) product. The lower count of *Staphylococci* and yeast and mould count in the products can be attributed to hygienic processing conditions, cooking time and temperature (175 °C, 40 min.) combination employed, antimicrobial and antifungal activity of aloe vera (Kaithwas et al. 2008; Khaing 2011) and packaging material and methods used. Coliforms were not at all detected throughout the storage period. These findings are in consonance with studies of Kumar and Sharma (2004) in low fat patties.

Sensory quality

Sensory quality attributes of control and EGMB were significantly ($p<0.05$) influenced by packaging methodologies (Table 6) under refrigerated storage conditions (4±1 °C). Colour and appearance scores were comparable in all the treated products in both the packaging groups up to 14th day. However, sensory panellists rated MAP packaged product higher than aerobic packaged product on subsequent storage. The colour and appearance scores followed a declining trend throughout the storage period in both the packaging groups. These observations can also be correlated with the instrumental colour profile.

Flavour scores were significantly ($p<0.05$) higher in treated products than control throughout the study period except 0 and 7th day. The aerobic control (T-1) and aerobic treated

Table 5 Microbiological quality of EGMB stored at refrigeration temperature (4±1 °C) under aerobic and modified atmosphere packaging (MAP) conditions

Treatments/Days	Day 0	Day 7	Day 14	Day 21	Day 28	Day 35	Day 42
SPC (log ₁₀ cfu/g)							
T-1	2.29±0.01 ^{Ba}	2.61±0.01 ^{Db}	2.85±0.01 ^{Dc}	3.16±0.01 ^{Dd}	4.99±0.01 ^{De}	5.76±0.01 ^{Df}	NP
T-2	2.26±0.02 ^{ABa}	2.47±0.02 ^{Cb}	2.76±0.01 ^{Cc}	2.99±0.01 ^{Cd}	3.19±0.01 ^{Ce}	4.15±0.01 ^{Cf}	NP
T-3	2.27±0.02 ^{ABa}	1.51±0.02 ^{Bb}	1.74±0.01 ^{Bc}	1.83±0.01 ^{Bd}	1.97±0.01 ^{Be}	2.49±0.01 ^{Bf}	3.01±0.02 ^{Bg}
T-4	2.23±0.02 ^{Aa}	1.41±0.02 ^{Ab}	1.58±0.01 ^{Ac}	1.76±0.01 ^{Ad}	1.89±0.01 ^{Ae}	2.01±0.01 ^{Af}	2.67±0.01 ^{Ag}
<i>Staphylococci</i> count (log ₁₀ cfu/g)							
T-1	ND	ND	ND	ND	1.58±0.03	NP	NP
T-2	ND	ND	ND	ND	ND	1.241±0.06	NP
T-3	ND	ND	ND	ND	ND	ND	ND
T-4	ND	ND	ND	ND	ND	ND	ND
Yeast and mould count (log ₁₀ cfu/g)							
T-1	ND	ND	ND	ND	1.73±0.12	NP	NP
T-2	ND	ND	ND	ND	ND	1.53±0.02	NP
T-3	ND	ND	ND	ND	ND	ND	ND
T-4	ND	ND	ND	ND	ND	ND	ND

$n=6$; NP=not performed; ND=not detected; C=Aerobic control, T-1=Aerobic treated, T-3=MAP control, T-4=MAP treated

Mean±S.E. with different superscripts row wise (small alphabets) and column wise (capital alphabets) differ significantly ($p<0.05$)

Table 6 Sensory quality of EGMB stored at refrigeration temperature ($4\pm 1\text{ }^{\circ}\text{C}$) under aerobic and modified atmosphere packaging (MAP) conditions

Treatments/Days	Day 0	Day 7	Day 14	Day 21	Day28	Day 35	Day 42
Colour and appearance							
T-1	6.39 $\pm$ 0.04 ^{Ae}	6.08 $\pm$ 0.061 ^{Ad}	5.86 $\pm$ 0.07 ^{Ac}	5.44 $\pm$ 0.06 ^{Ab}	5.27 $\pm$ 0.05 ^{Aa}	NP	NP
T-2	7.41 $\pm$ 0.05 ^{Be}	7.31 $\pm$ 0.09 ^{Cde}	7.16 $\pm$ 0.10 ^{Bd}	7.01 $\pm$ 0.02 ^{Bc}	6.83 $\pm$ 0.08 ^{Cb}	6.63 $\pm$ 0.03 ^{Ba}	NP
T-3	6.41 $\pm$ 0.04 ^{Ad}	6.27 $\pm$ 0.06 ^{Bd}	5.89 $\pm$ 0.06 ^{Ac}	5.52 $\pm$ 0.07 ^{Ab}	5.45 $\pm$ 0.05 ^{Bb}	5.19 $\pm$ 0.05 ^{Aa}	5.05 $\pm$ 0.03 ^{Aa}
T-4	7.42 $\pm$ 0.01 ^{Bd}	7.38 $\pm$ 0.06 ^{Cd}	7.30 $\pm$ 0.07 ^{Bcd}	7.19 $\pm$ 0.06 ^{Cbc}	7.08 $\pm$ 0.05 ^{Db}	6.91 $\pm$ 0.06 ^{Ca}	6.77 $\pm$ 0.03 ^{Ba}
Flavour							
T-1	6.36 $\pm$ 0.05 ^{Ae}	6.08 $\pm$ 0.01 ^{Ad}	5.75 $\pm$ 0.08 ^{Ac}	5.38 $\pm$ 0.05 ^{Ab}	5.22 $\pm$ 0.06 ^{Aa}	NP	NP
T-2	7.46 $\pm$ 0.02 ^{Bd}	7.32 $\pm$ 0.05 ^{Cd}	7.15 $\pm$ 0.05 ^{Cc}	7.02 $\pm$ 0.07 ^{Cc}	6.76 $\pm$ 0.05 ^{Bb}	6.52 $\pm$ 0.08 ^{Ba}	NP
T-3	6.38 $\pm$ 0.03 ^{Ae}	6.27 $\pm$ 0.02 ^{Be}	5.86 $\pm$ 0.12 ^{Bd}	5.63 $\pm$ 0.09 ^{Bc}	5.38 $\pm$ 0.02 ^{Ab}	5.19 $\pm$ 0.05 ^{Aa}	5.02 $\pm$ 0.02 ^{Aa}
T-4	7.46 $\pm$ 0.03 ^{Be}	7.41 $\pm$ 0.04 ^{Ce}	7.29 $\pm$ 0.06 ^{Dde}	7.23 $\pm$ 0.07 ^{Dcd}	7.07 $\pm$ 0.06 ^{Cc}	6.90 $\pm$ 0.05 ^{Cb}	6.65 $\pm$ 0.08 ^{Ba}
Texture/Tenderness							
T-1	6.16 $\pm$ 0.07 ^{Ae}	5.94 $\pm$ 0.05 ^{Ad}	5.69 $\pm$ 0.06 ^{Ac}	5.36 $\pm$ 0.06 ^{Ab}	5.16 $\pm$ 0.06 ^{Aa}	NP	NP
T-2	7.27 $\pm$ 0.07 ^{Be}	7.19 $\pm$ 0.05 ^{Cde}	7.08 $\pm$ 0.06 ^{Bcd}	6.96 $\pm$ 0.13 ^{Bc}	6.77 $\pm$ 0.31 ^{Bb}	6.55 $\pm$ 0.05 ^{Ba}	NP
T-3	6.27 $\pm$ 0.01 ^{Ad}	6.16 $\pm$ 0.05 ^{Bd}	5.86 $\pm$ 0.02 ^{Ac}	5.47 $\pm$ 0.07 ^{Ab}	5.33 $\pm$ 0.03 ^{Ab}	5.09 $\pm$ 0.06 ^{Aa}	4.94 $\pm$ 0.04 ^{Aa}
T-4	7.36 $\pm$ 0.02 ^{Be}	7.38 $\pm$ 0.06 ^{De}	7.25 $\pm$ 0.06 ^{Bde}	7.18 $\pm$ 0.07 ^{Cc}	7.02 $\pm$ 0.06 ^{Cb}	6.85 $\pm$ 0.08 ^{Ca}	6.71 $\pm$ 0.05 ^{Ba}
Crispiness							
T-1	6.25 $\pm$ 0.06 ^{Ad}	6.02 $\pm$ 0.07 ^{Ac}	5.69 $\pm$ 0.08 ^{Ab}	5.39 $\pm$ 0.06 ^{Aa}	5.22 $\pm$ 0.05 ^{Aa}	NP	NP
T-2	7.36 $\pm$ 0.06 ^{Be}	7.30 $\pm$ 0.07 ^{Bde}	7.16 $\pm$ 0.02 ^{Bd}	6.97 $\pm$ 0.08 ^{Bc}	6.78 $\pm$ 0.05 ^{Cb}	6.57 $\pm$ 0.05 ^{Ba}	NP
T-3	6.30 $\pm$ 0.04 ^{Ad}	6.16 $\pm$ 0.02 ^{Ad}	5.86 $\pm$ 0.07 ^{Ac}	5.52 $\pm$ 0.06 ^{Ab}	5.41 $\pm$ 0.07 ^{Bb}	5.16 $\pm$ 0.04 ^{Aa}	5.02 $\pm$ 0.03 ^{Aa}
T-4	7.38 $\pm$ 0.06 ^{Be}	7.36 $\pm$ 0.08 ^{Be}	7.25 $\pm$ 0.08 ^{Bde}	7.16 $\pm$ 0.09 ^{Ccd}	7.05 $\pm$ 0.03 ^{Dc}	6.88 $\pm$ 0.04 ^{Cb}	6.69 $\pm$ 0.04 ^{Ba}
Juiciness							
T-1	6.25 $\pm$ 0.05 ^{Ae}	6.02 $\pm$ 0.06 ^{Ad}	5.66 $\pm$ 0.06 ^{Ac}	5.38 $\pm$ 0.03 ^{Ab}	5.22 $\pm$ 0.07 ^{Aa}	NP	NP
T-2	7.36 $\pm$ 0.05 ^{Be}	7.30 $\pm$ 0.04 ^{Ce}	7.13 $\pm$ 0.12 ^{Bd}	6.97 $\pm$ 0.05 ^{Ccd}	6.83 $\pm$ 0.08 ^{Cb}	6.61 $\pm$ 0.014 ^{Ba}	NP
T-3	6.32 $\pm$ 0.070 ^{Ad}	6.22 $\pm$ 0.07 ^{Bd}	5.83 $\pm$ 0.07 ^{Ac}	5.56 $\pm$ 0.07 ^{Bc}	5.41 $\pm$ 0.09 ^{Bb}	5.16 $\pm$ 0.03 ^{Aa}	5.08 $\pm$ 0.10 ^{Aa}
T-4	7.41 $\pm$ 0.12 ^{Be}	7.35 $\pm$ 0.17 ^{Cde}	7.27 $\pm$ 0.10 ^{Bde}	7.19 $\pm$ 0.03 ^{Dcd}	7.06 $\pm$ 0.04 ^{Dc}	6.88 $\pm$ 0.03 ^{Cb}	6.72 $\pm$ 0.07 ^{Ba}
Overall acceptability							
T-1	6.36 $\pm$ 0.06 ^{Ae}	6.11 $\pm$ 0.07 ^{Ad}	5.75 $\pm$ 0.01 ^{Ac}	5.38 $\pm$ 0.07 ^{Ab}	5.22 $\pm$ 0.07 ^{Aa}	NP	NP
T-2	7.38 $\pm$ 0.08 ^{Bd}	7.33 $\pm$ 0.05 ^{Bd}	7.15 $\pm$ 0.02 ^{Bc}	7.02 $\pm$ 0.06 ^{Bc}	6.83 $\pm$ 0.07 ^{Bb}	6.67 $\pm$ 0.01 ^{Ba}	NP
T-3	6.38 $\pm$ 0.04 ^{Ad}	6.22 $\pm$ 0.07 ^{Ad}	5.91 $\pm$ 0.05 ^{Ac}	5.52 $\pm$ 0.06 ^{Ab}	5.38 $\pm$ 0.06 ^{Ab}	5.16 $\pm$ 0.09 ^{Aa}	5.05 $\pm$ 0.07 ^{Aa}
T-4	7.46 $\pm$ 0.02 ^{Bf}	7.37 $\pm$ 0.08 ^{Bef}	7.29 $\pm$ 0.08 ^{Bde}	7.19 $\pm$ 0.53 ^{Bcd}	7.08 $\pm$ 0.14 ^{Bc}	6.91 $\pm$ 0.02 ^{Cb}	6.75 $\pm$ 0.08 ^{Ba}

$n=18$; NP=not performed; C=Aerobic control, T-1=Aerobic treated, T-3=MAP control, T-4=MAP treated

*Mean $\pm$ S.E. with different superscripts row wise (small alphabets) and column wise (capital alphabets) differ significantly ($p<0.05$)

products (T-2) exhibited off odour 35th and 42nd day, respectively. Hence, sensory evaluation was not conducted for these products on above mentioned days. These results are in consonance with the higher values of TBARS (Fig. 1). Texture and juiciness scores were comparable in treated products up to 14th day in both the package groups, however thereafter, TBARS was better in MAP products. Texture and juiciness scores followed a declining trend in all the products during storage irrespective of packaging materials and methods. This can be attributed to higher moisture loss occurred in aerobic packaged products than MAP packaged product, which lead to harder texture and lower juiciness.

Crispiness scores were also comparable in treated products up to 14th day in both the packaged groups and thereafter, significantly ($p<0.05$) higher in T-4. The sensory scores also

followed a declining trend throughout the storage, which can be attributed to packaging materials and methods to maintain the crispiness. The overall acceptability scores were also significantly ($p<0.05$) higher in treated products than control. The sensory panellists have awarded significantly ($p<0.05$) higher scores to the MAP packaged product than aerobic packaged product, irrespective of type of treatment. The sensory panellists rated the EGMB MAP packaging acceptable even on 42nd day, the last day of storage.

Results concluded that the enrobed goat meat bites can be successfully stored up to 35th day in aerobic packaging conditions and for more than 42 days in MAP conditions at refrigerated temperature with acceptable sensory quality attributes, physico-chemical and microbiological quality with a safer permissible level.

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