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# Application of alginate and gelatin-based edible coating materials as alternatives to traditional coating for improving the quality of pastirma

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**Abstract** This research was conducted to study the efficacy of sodium alginate and gelatin coating materials in improving the quality of pastirma. Pastirma was coated with traditional, alginate or gelatin coatings, stored at 4 °C for 4 weeks and examined weekly. Alginate and gelatin coated-pastirma revealed lower TBARS values which was within the acceptable limit (0.67 and 0.86 mg/kg) until the end of storage, however, the TBARS values of traditionally coated pastirma reached 1.33 by the end of storage. Edible coating delayed respiration rate with improvement of the color when compared with traditionally coated one. Oxygen concentration increased from 4.21 mg/kg/h in traditionally coated pastirma to 12.56 and 9.79 in alginate and gelatin coated ones, respectively. Meanwhile, $CO_2$ concentration decreased from 10.40 mg/kg/h in traditionally coated pastirma to 4.89 and 6.07 mg/kg/h in alginate and gelatin coated ones, respectively. Moreover, a distinct improvement in all sensory attributes has been observed.

**Keywords** Pastirma · Alginate · Gelatin · Respiration rate · Sensory quality

## Introduction

Pastirma is one of the most common dry-cured meat products that are greatly produced worldwide. During processing of pastirma, nitrates and/or nitrites in combination with salt should be added to develop a characteristic cured color and flavor as well as to inhibit the growth of spoilage and foodborne pathogens (Tekinsen and Dogruer, 2000). After curing, pastirma should be wrapped with a paste composed of ground fenugreek, fresh ground garlic and paprika powder called cemen (Saito et al., 2009).

The color of dry-cured meat is mostly affected by packaging materials, added nitrate and salt, microorganisms as well as the oxygen and carbon dioxide tension in the surrounding atmosphere (Luo et al., 2013). Although traditional coating plays a significant role in keeping the quality characteristics of pastirma (Gök et al., 2008), it harmfully affects its color. Additionally, the salt can adversely affect the color of meat products through promotion of lipid oxidation and acceleration of met-myoglobin formation with consequent meat discoloration; moreover, nitrite reacts with water in meat products and forms nitric oxide which combines with myoglobin to form unstable color compound called nitric-oxide-myoglobin (Gheisri and Motamedi, 2010).

The instability of dry cured-meat color forced the manufacturers to use vacuum packaging or modified atmosphere packaging (Falguera et al., 2011). Although they were widely introduced in meat processing, they revealed many problems which finally limited their use. These problems include color and texture modifications, loss of chemical, biological and sensory quality due to the interaction between the food and the packaging materials (Garcia-Segovia et al., 2007), Moreover, they are expensive, have health risk from added gases and may result in loss of preservation effect once the package has been opened as well as liquid exudation, product deformation and high volume of waste plastic materials (Santos et al., 2005).

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Edible biodegradable coatings were introduced recently for meat products as cost effective alternative coating materials to overcome aforementioned problems and to improve the quality characteristics (Brasil et al., 2012). Furthermore, they may have the ability to prolong the natural color of meat products by limiting moisture and gas exchange (Kang et al., 2013). The edible coatings may be derived from proteins, carbohydrates and lipids. Proteins (gelatin, casein, whey) and carbohydrates (alginates, starch, carrageenan) based edible coatings are of high interest (Vanzela et al., 2013), which may provide an advanced food protection approach to satisfy the customer demand (Baldwin et al., 2011). Alginate and gelatin are the most commonly used materials for edible coatings. They are commonly available, easily prepared, and cost effective to be introduced as a novel trend for edible coating to preserve color and quality of pastirma with minimal environmental pollutions. Alginate is characterized by its gelling properties, antibacterial activity as well as its ability to delay the respiration rate and improve the color, juiciness, texture and odor. Gelatin is characterized by excellent coating characteristics and thermo-reversible properties, good barrier properties as well as antioxidant activities (Gómez-Guillén et al., 2011).

Alginate and gelatin are widely used as thickening, suspending, gel producing, and emulsion stabilizing agents in meat products as well as coating materials for fruits and vegetables. However, their application as coatings in meat products is limited; therefore, the main objective of the present work was to study the efficacy of alginate and gelatin as coating materials in improving the color as well as microbiological characteristics and sensory attributes of pastirma during storage at 4 °C for 4 weeks.

## Materials and methods

### Raw materials

Food grade sodium alginate was purchased from Qingdao Rongde Sea Weed Co. (China). Halal gelatin was purchased from Henan Yach Gelatin Co. (China). Garlic, fenugreek and cumin oleoresins were purchased from Nubassa Gewürzwerk GmpH (Viernheim, Germany). Sodium nitrite was obtained from BASF, Chemical Company, Ludwigshafen Rhine, Germany. Glycerol was obtained from Sigma-Aldrich (St. Louis, MO, USA). Common salt, calcium chloride, fenugreek powder, capsicum powder and fresh garlic were obtained from local market at Giza, Egypt.

### Curing mixture

A dry curing mixture composed of Common salt 50 kg/100 kg, Sodium nitrite 75 mg/100 kg, Garlic oleoresin 10 ml/100 kg, Fenugreek oleoresin 50 ml/100 kg, Cumin oleoresin 10 ml/100 kg and 500 g/100 kg was prepared.

### Curing process

Deep frozen Brazilian beef *semitendinosus* muscles (about 2 kg) were completely thawed and all trimmable fat and connective tissue were removed. Four knife stabs were performed in each muscle and the muscles were rubbed with the curing mixture. The rubbed muscles were arranged in layers with curing mixture in between at 4 °C for 12 h, then re-arranged and kept for further 12 h. After curing, meat was washed with running water, desalinated in water tank for 2 h, hanged to drip for 1 h, wrapped in cotton sheets. Wrapped meat were pressed at 0.01 kg/m$^2$ for 24 h using hydraulic pressing machine and finally dried at 50 °C for 30 min.

### Preparation of coating materials

For preparation of traditional coat, a dry mixture of fenugreek powder, paprika powder and fresh ground garlic (2:0.5:1) was rendered into a uniform paste with a quantum sufficient of water.

Sodium alginate and gelatin coatings were prepared into solutions at concentrations of 2%. Alginate coating was prepared by the method of Rojas-Grau et al. (2007) with some modifications. Twenty grams of sodium alginate were dissolved in 250 ml distilled water and stirred at 80 °C until clear solution was obtained followed by addition of 25 mL glycerol as a plasticizing agent, mixed and completed to 1 L by distilled water. However, gelatin coating was prepared according to the method of Antoniewski et al. (2007) with some modification. Twenty grams of gelatin were dissolved in 1 L distilled water followed by addition of 25 mL of glycerol, stirred at 60 °C for 30 min then filtered. Two percent (w/v) calcium chloride was also prepared. All coating materials were cooled to room temperature prior to surface application onto dry-cured meat.

### Coating of pastirma

Dried pastirma were divided into three portions for application of coating materials. The first portion was wrapped with a thin regular layer of traditional coat formed from a mixture of fenugreek powder, paprika powder and fresh ground garlic. However, the edible coating materials (alginate and gelatin solutions) were applied by immersing

the dry-cured meat in these solutions for 2 min then hanging it to drip excess solution for 1 min followed by re-dipping for another 1 min. After that the coated dry-cured meats were dipped in a solution of 2% (w/v) calcium chloride for 1 min to strengthen the formed coat gel. All coated dry-cured meats were dried at 50 °C for 15 min and kept in cool dry place for 24 h then stored at 4 °C for 4 weeks. Samples were withdrawn and examined after 24 h (0-time) and every week for 1 month.

### Examination of pastirma

Three samples from each trial were analyzed for physico-chemical parameters (instrumental color, respiration rate, TBARS, weight loss, residual nitrite and salt), microbiological quality, shear force and sensory attributes.

### Physico-chemical parameters

#### *Instrumental color measurement*

Instrumental color of each pastirma sample was determined by a colorimeter (Konica Chroma meter, model CR 410, Japan) calibrated with a white plate (L* = + 97.83, a* = 0.43, b* = + 1.98). Six readings for each of three replicates of pastirma samples were obtained. Values for Lightness (L*), redness (a*), and yellowness (b*) were obtained and the average was recorded (Shin et al., 2008).

#### *Respiration rate*

The respiration rate, expressed in mg/kg/h was determined according to the method of Demirdoven and Batu (2004) by incubating one kilogram coated pastirma of known mass and volume in 7 L hermetically sealed genbox jar for 1 h. After that the oxygen and carbon dioxide concentrations were determined in the head space of the jar by means of a Systech Gaspace advance GS3L gas analyzer.

### Measurement of thiobarbituric acid reactive substances (TBARS)

The thiobarbituric acid reactive substances (TBARS) value was measured by the method outlined by (Du and Ahn, 2002) and expressed as milligrams of malonaldehyde per kilogram of sample.

### Weight loss analysis

The weight loss of pastirma was calculated as loss in weight of sample during storage and the values were reported on a percentage basis. The following formula was used to calculate the weight loss percentage: (Initial weight − weight in the specific time of storage)/initial weight × 100.

### Determination of residual nitrite and salt

The residual nitrites expressed as ppm and salt concentrations expressed as percentage were determined according to AOAC (2000).

### Microbiological examination

Ten grams from each pastirma sample were homogenized with 90-mL sterile Ringer's solution (Merck, Darmstadt, Germany) for 2 min using Lab blender (400, Seward, model 6021, London UK). From the original solution, tenfold decimal dilution was prepared. The spreading technique and the standard plate count agar were used for enumeration of aerobic plate count (APC) according to Swanson et al. (2001). Moreover, molds were enumerated by inoculation of plates of Sabaroud dextrose agar (Merck, Darmstadt, Germany) followed by incubation at 25 °C for 5 days (Beuchat and Cousin, 2001).

### Sensory investigations

Sensory analysis was performed following the AMSA (1995) guidelines. Eleven experienced panelists of both sexes (25–40 years) were selected from faculty members and postgraduate students of the Department of Food Hygiene and Control, Faculty of Veterinary Medicine, Cairo University, Egypt. Before examination, two training sessions were conducted to ensure that each panelist could accurately evaluate each investigated parameter. All testing was carried out under controlled atmosphere with tap water available to cleanse the palate between samples. Each panelist received three replicates of pastirma in a form of slices and asked to evaluate appearance, juiciness, tenderness and overall acceptability using 1–9 hedonic scale, where 9 indicate extremely acceptable and 1 indicates extremely unacceptable.

### Statistical analysis

The SPSS program (v.22, IBM SPSS Inc.; Chicago, IL, USA) was used to statistically analyze the data. The statistical significance ($P < 0.05$) of the effect of coat type was evaluated by one-way analysis of variance (ANOVA). However, the two-way ANOVA was used to analyze the effect of coat type formulation and storage time. The coat type and storage time was assigned as fixed effects and replication as a random effect. The values in the tables are given in terms of mean values and standard error of the mean. Least squares differences (LSD) were used for

comparison of mean values among coat type and Tukey's HSD test to identify significant differences ($P < 0.05$) between coat type and storage time.

## Result and discussion

### Physico-chemical parameters

*Instrumental color*

Coating pastirma with edible coating materials (gelatin and alginate) resulted in significant ($P < 0.05$) reduction of lightness (L*) values, significant ($P < 0.05$) elevation of redness (a*) values and yellowness (b*) values when compared with traditional coating material. Meanwhile, the pastirma coated with gelatin revealed significant ($P < 0.05$) reduction in lightness (L*) values, significant ($P < 0.05$) elevation in redness (a*) values and non-significant ($P > 0.05$) increase in yellowness (b*) values when compared with those of alginate coated one at 0-time and during storage period. Storage of coated pastirma at 4 °C for 4 weeks with all coated materials resulted in significant ($P < 0.05$) decrease of L* and a* values and significant ($P < 0.05$) increase of b* values (Table 1). The higher a* and lower b* values obtained in gelatin coated pastirma may be explained by the gas barrier and antioxidant properties of gelatin which prevent oxidation of meat. These observations were in good agreement with Villegas et al. (1999) who recorded that gelatin coating was effective in improving meat redness. Moreover, it has been noticed that gelatin-based coatings reduced meat discoloration during the storage by reducing the L* values of coated beef tenderloin which was in good agreement with Antoniewski et al. (2007). Therefore, the color of pastirma has been preserved after coating with gelatin or alginate and this observation will make the dry cured meat more attractive to consumers.

*Respiration rate*

The respiration rate of carbon dioxide ($CO_2$) and oxygen ($O_2$) of pastirma coated with traditional and edible coating materials are presented in Table 2. Application of alginate and gelatin coating to pastirma significantly ($P < 0.05$) delayed the respiration process when compared with traditional coat. This delaying in the respiration process was manifested by maintaining a lower $CO_2$ level and higher $O_2$ concentration in the headspace during storage. The traditionally coated pastirma revealed a significant ($P < 0.05$) increase in $CO_2$ level and a significant ($P < 0.05$) decrease in $O_2$ level during storage and this may be explained by the microbial growth. The $CO_2$ concentration of alginate and gelatin coated pastirma revealed high level at 0-time which started to be reduced by storage until the 3rd week then re-increased again at the 4th week. The higher level of $CO_2$ in alginate and gelatin coated pastirma at 0-time may be attributed to the stress applied on meat during processing operations as handling, trimming, curing and coating. However, the re-elevation of the

**Table 1** Instrumental color values of pastirma coated with traditional, gelatin and alginate coatings during storage at 4 °C for 4 weeks

| | Color measurement* | | | | |
|---|---|---|---|---|---|
| | 0-time | 1st week | 2nd week | 3rd week | 4th week |
| Lightness (L*) | | | | | |
| Traditional | 40.33 ± 0.14av | 36.32 ± 0.20aw | 35.82 ± 0.09aw | 34.15 ± 0.19ax | 33.52 ± 0.14ay |
| Gelatin | 34.90 ± 1.65bv | 33.86 ± 0.25bvw | 32.50 ± 0.11bvw | 31.95 ± 0.38bwx | 29.55 ± 0.25bx |
| Alginate | 38.26 ± 0.11cv | 34.52 ± 0.10cw | 34.22 ± 0.14cw | 32.17 ± 0.16bx | 31.41 ± 0.24cy |
| Redness (a*) | | | | | |
| Traditional | 13.16 ± 0.45av | 12.62 ± 0.17aw | 10.33 ± 0.35aw | 10.05 ± 0.13ax | 9.57 ± 0.31ay |
| Gelatin | 18.06 ± 0.95bv | 13.92 ± 0.13bw | 13.52 ± 0.35bw | 12.09 ± 0.30ax | 10.87 ± 0.15by |
| Alginate | 15.91 ± 0.77bv | 13.83 ± 0.19bw | 11.36 ± 0.22cx | 10.91 ± 0.15cxy | 10.74 ± 0.11by |
| Yellowness (b*) | | | | | |
| Traditional | 4.22 ± 0.15av | 5.19 ± 0.12av | 5.88 ± 0.54aw | 6.15 ± 0.14awx | 6.65 ± 0.26ax |
| Gelatin | 5.53 ± 0.19bv | 5.79 ± 0.20bv | 6.85 ± 0.20bw | 7.05 ± 0.11bw | 8.38 ± 0.50bx |
| Alginate | 5.06 ± 0.15bv | 5.41 ± 0.12av | 6.67 ± 0.18bw | 6.75 ± 0.19cw | 7.20 ± 0.23cx |

*Values represent the mean of three independent replicates ± standard error

[a–c]Values with different superscripts within the same column are significantly ($P < 0.05$) different

[v–y]Values with different superscripts within the same raw are significantly ($P < 0.05$) different

**Table 2** Respiration rate and TBARS values of pastirma coated with traditional, gelatin and alginate coatings during storage at 4 °C for 4 weeks

| Respiration rate (mg/kg/h)* | | | | | |
|---|---|---|---|---|---|
| | 0-time | 1st week | 2nd week | 3rd week | 4th week |
| $CO_2$ (mg/kg/h) | | | | | |
| Traditional | 6.46 ± 0.12av | 6.78 ± 0.17av | 6.76 ± 0.29av | 8.42 ± 0.22aw | 10.40 ± 0.12ax |
| Gelatin | 4.98 ± 0.14cv | 3.88 ± 0.12cvw | 3.55 ± 0.18bw | 3.55 ± 0.23bw | 4.89 ± 0.12bx |
| Alginate | 5.36 ± 0.09bv | 4.73 ± 0.30bw | 3.70 ± 0.18bvw | 3.70 ± 0.33bw | 6.07 ± 0.11cx |
| $O_2$ (mg/kg/h) | | | | | |
| Traditional | 15.56 ± 0.14av | 13.45 ± 0.13aw | 12.70 ± 0.27aw | 6.42 ± 0.19ax | 4.21 ± 0.15ay |
| Gelatin | 18.23 ± 0.29bv | 17.04 ± 0.30bv | 14.15 ± 0.09bw | 14.55 ± 0.26bw | 12.56 ± 0.11bx |
| Alginate | 16.56 ± 0.30cv | 15.75 ± 0.22cv | 13.20 ± 0.11aw | 12.99 ± 0.33cw | 9.79 ± 0.22cx |
| TBARS (mg/kg) | | | | | |
| Traditional | 0.79 ± 0.01av | 0.84 ± 0.12av | 0.99 ± 0.03av | 0.99 ± 0.04av | 1.33 ± 0.07aw |
| Gelatin | 0.36 ± 0.02bv | 0.58 ± 0.02bw | 0.58 ± 0.05bw | 0.62 ± 0.02bw | 0.67 ± 0.05bx |
| Alginate | 0.77 ± 0.03av | 0.79 ± 0.01av | 0.83 ± 0.02cv | 0.85 ± 0.03cv | 0.86 ± 0.08cv |

*Values represent the mean of three independent replicates ± standard error

[a–c]Values with different superscripts within the same column are significantly ($P < 0.05$) different

[v–y]Values with different superscripts within the same raw are significantly ($P < 0.05$) different

$CO_2$ level at the last week of storage may be explained by microbial growth. The results revealed a delayed respiration rate in alginate and gelatin coated pastirma during the 1st to 3rd week of storage period. This delayed respiration rate may be attributed to the excellent gas barrier activity resulted from its higher contents of polymers containing groups that can react with hydrogen bonds and the hygroscopic properties which enable creating modified atmosphere (Morillon et al., 2002). Moreover, the results revealed a more delayed respiration rate in pastirma coated with gelatin than with alginate, which was in a good agreement with Ou et al. (2004) who stated that protein-based coatings have impressive gas barrier compared with carbohydrate based coatings.

It has been established that anaerobic condition will start and the Krebs cycle will be replaced when oxygen level drops below 8% with the resulting glycolytic pathway releasing unacceptable flavors and causing color and texture problems. Higher oxygen levels (> 8%) and lower carbon dioxide levels (< 5%) can result in modified atmospheric condition which, delay deterioration and keep meat quality with extension of shelf life of the product. This explanation has been clarified by Conca (2002) who observed that high $O_2$ concentration delayed color deterioration, improved product quality and extend the shelf life.

## Thiobarbituric acid reactive substances (TBARS)

TBRAS values of gelatin coated pastirma were significantly ($P < 0.05$) lower than those of traditionally coated pastirma after processing (0-time) and during chilled storage. Alginate coated pastirma revealed non-significant ($P > 0.05$) reduction of TBARS values during the 1st week of storage and significant ($P < 0.05$) lowering at the 2nd, 3rd and 4th weeks of storage in comparison with those of traditionally coated. Moreover, the TBARS values of gelatin coated pastirma were significantly ($P < 0.05$) lower than those of alginate coated pastirma (Table 2). These results indicated that gelatin coating of pastirma exhibited noticeable antioxidant activities when compared with alginate and traditional coating. These observations were in good agreement with Antoniewski et al. (2007) who recorded a distinct inhibition of the lipid oxidation in protein-based coat in comparison with carbohydrate-based coat. The antioxidant activity of gelatin has been explained by its ability to inactivate reactive oxygen species, scavenging free radicals and chelate pro-oxidative metals (Elias et al., 2008). Moreover, it has been reported that gelatin contains specific peptides and amino acids such as histidine, leucine, proline and glycin, which inhibit lipid oxidation and play an important role in the radical scavenging ability (Mendis et al., 2005). The lowering TBARS values of edible coated pastirma may be connected with maintenance of the color of the pastirma through retardation of myoglobin oxidation and met-myoglobin formation.

## Weight loss

Both alginate and gelatin coating resulted in significant ($P < 0.05$) reduction in the weight loss of pastirma at

0-time and during refrigerated when compared with control pastirma. The weight loss of gelatin coated pastirma was significantly ($P < 0.05$) lower than that of alginate coated one. Storage of pastirma coated with traditional, gelatin and alginate coatings resulted in significant ($P < 0.05$) increase in weight loss (Table 3). The variations in weight loss among coated pastirma are a good indication to the variation in permeability of the coating materials. The obtained results were in agreement with those of Shon and Haque (2007) who reported that gelatin is better than alginate in reducing weight loss due to its hydrophobic nature. It has been reported that gelatin has high surface tension properties that can decrease water migration and retard weight loss from food products (Antoniewski et al., 2007). However, alginate exhibit poor water resistance because of its hydrophilic nature (Borchard et al., 2005).

## Residual nitrite and salt

Residual nitrite values (ppm) of alginate and gelatin coated pastirma were significantly ($P < 0.05$) lower than those of control (Table 4). However, the values of alginate coated pastirma were significantly ($P < 0.05$) lower than those of gelatin coated one. Additionally, residual nitrites revealed significant ($P < 0.05$) reduction during storage in all coated pastirma. The reduction of the residual nitrite contents in alginate and gelatin coated pastirma may be attributed to the consumption of higher amounts of nitrite during reaction with myoglobin to produce the desired cured color (Panthitra and Contipra, 2005). This may explain the improvement of color in alginate and gelatin coated pastirma. However, the higher residual nitrite contents in traditionally coated pastirma may be attributed to the higher weight loss which resulted in lower available water for nitrite to form nitrous acid and nitric oxide that combine with myoglobin to form nitric oxide myoglobin with consequent adverse effect on the color.

Coating of pastirma with alginate and gelatin material resulted in significant ($P < 0.05$) reduction in salt contents when compared with traditionally coated pastirma at 0-time and during chilled storage (Table 4). Salt values were gradually increased during storage and this may be explained by the increasing of weight loss which mostly water loss that lead to concentration of salt. It has been reported that salt act as a pro-oxidant agent in meat product by disrupting the cell membrane integrity, which facilitate the access of oxidizing agents, liberation of iron ions from myoglobin and inhibition of the activity of antioxidant

**Table 3** Weight loss values of pastirma coated with traditional, gelatin and alginate coatings during storage at 4 °C for 4 weeks

| Weight loss* | | | | |
|---|---|---|---|---|
| | 1st week | 2nd week | 3rd week | 4th week |
| Traditional | 2.50 ± 0.58av | 3.19 ± 0.45av | 9.77 ± 0.40aw | 11.37 ± 0.09ax |
| Gelatin | 0.35 ± 0.05bv | 1.47 ± 0.03bw | 5.46 ± 0.08bx | 6.30 ± 0.07by |
| Alginate | 1.02 ± 0.11cv | 1.81 ± 0.01cv | 7.77 ± 0.18cw | 8.83 ± 0.20cw |

*Values represent the mean of three independent replicates ± standard error

[a–c]Values with different superscripts within the same column are significantly ($P < 0.05$) different

[v–y]Values with different superscripts within the same raw are significantly ($P < 0.05$) different

**Table 4** Residual nitrite and salt values of pastirma coated with traditional, gelatin and alginate coatings during storage at 4 °C for 4 weeks

| | 0-time | 1st week | 2nd week | 3rd week | 4th week |
|---|---|---|---|---|---|
| Nitrite (ppm)* | | | | | |
| Traditional | 72.96 ± 4.17av | 72.20 ± 2.66av | 24.32 ± 2.31aw | 23.42 ± 0.38aw | 22.04 ± 2.12aw |
| Gelatin | 57.63 ± 2.76bv | 54.91 ± 2.74bv | 23.15 ± 2.31aw | 22.12 ± 0.31abw | 19.38 ± 1.32abw |
| Alginate | 52.06 ± 1.75cv | 49.40 ± 2.97cv | 23.18 ± 1.66aw | 17.86 ± 1.37bw | 16.34 ± 1.01bw |
| Salt (%) | | | | | |
| Traditional | 7.83 ± 0.02av | 7.93 ± 0.02aw | 8.00 ± 0.02ax | 8.00 ± 0.02ax | 8.01 ± 0.33ax |
| Gelatin | 7.67 ± 0.04bvw | 7.75 ± 0.05bw | 7.77 ± 0.19bw | 7.94 ± 0.03ax | 7.99 ± 0.28ax |
| Alginate | 7.69 ± 0.03bv | 7.77 ± 0.04bw | 7.80 ± 0.06bwx | 7.96 ± 0.01axy | 8.00 ± 0.13ay |

*Values represent the mean of three independent replicates ± standard error

[a-c]Values with different superscripts within the same column are significantly ($P < 0.05$) different

[v–y]Values with different superscripts within the same raw are significantly ($P < 0.05$) different

**Table 5** Microbiological profile of pastirma coated with traditional, gelatin and alginate coatings during storage at 4 °C for 4 weeks

| | Microbiological profile (log cfu/cm$^2$)* | | | | |
|---|---|---|---|---|---|
| | 0-time | 1st week | 2nd week | 3rd week | 4th week |
| APC | | | | | |
| Traditional | 5.73 ± 0.03av | 5.42 ± 0.18av | 4.88 ± 0.23aw | 4.43 ± 0.17aw | 4.09 ± 0.10aw |
| Gelatin | 4.32 ± 0.42bv | 3.78 ± 0.43bvw | 3.76 ± 0.29bvw | 3.42 ± 0.22bw | 3.40 ± 0.12bw |
| Alginate | 3.82 ± 0.59cv | 3.71 ± 0.14bv | 3.40 ± 0.43bw | 3.30 ± 0.17bw | 3.17 ± 0.15bw |
| Mold | | | | | |
| Traditional | 4.02 ± 0.17av | 3.53 ± 0.12aw | 2.67 ± 0.07ax | < 2.00 ± 0.00ay | < 2.00 ± 0.00ay |
| Gelatin | < 2.00 ± 0.00bv | < 2.00 ± 0.00bv | < 2.00 ± 0.00bv | < 2.00 ± 0.00av | < 2.00 ± 0.00av |
| Alginate | 2.30 ± 0.17cv | < 2.00 ± 0.00bw | < 2.00 ± 0.00bw | < 2.00 ± 0.00aw | < 2.00 ± 0.00aw |

*Values represent the mean of three independent replicates ± standard error

[a–c]Values with different superscripts within the same column are significantly ($P < 0.05$) different

[v–w]Values with different superscripts within the same raw are significantly ($P < 0.05$) different

enzymes (Overholt et al., 2016) with subsequent oxidation of pigments. Therefore, edible coating improved the color of pastirma through lowering of the salt concentration.

## Microbiological quality

The aerobic plate count (APC) and mold count of alginate and gelatin coated pastirma were significantly ($P < 0.05$) lower than those of traditionally coated one at 0-time and during chilled storage (Table 5). The lowering of microbial counts may be attributed to the gas barrier properties of alginate and gelatin (Ou et al., 2004) which reduced the available oxygen for aerobic bacteria. Moreover, the components of traditional coat (ground fenugreek seeds, fresh ground garlic, and paprika powder) which are always contaminated with mold were avoided in edible coated pastirma. The antibacterial activity of edible coating has been documented (Gómez-Guillén et al., 2011). The higher bacterial growth result in reduction of $O_2$ capacity with subsequent formation of met-myoglobin. Therefore, the

**Table 6** Sensory attributes of pastirma coated with traditional, gelatin and alginate coatings during storage at 4 °C for 4 weeks

| | Sensory attributes* | | | | |
|---|---|---|---|---|---|
| | 0-time | 1st week | 2nd week | 3rd week | 4th week |
| Appearance | | | | | |
| Traditional | 6.33 ± 0.33av | 6.33 ± 0.23av | 5.56 ± 0.11aw | 5.11 ± 0.11aw | 5.00 ± 0.19ax |
| Gelatin | 7.75 ± 0.46bv | 7.22 ± 0.11bw | 7.22 ± 0.22bw | 7.17 ± 0.41bw | 7.00 ± 0.19bw |
| Alginate | 8.08 ± 0.38bv | 7.67 ± 0.10bvw | 7.67 ± 0.19bvw | 7.56 ± 0.51bw | 7.45 ± 0.22bw |
| Juiciness | | | | | |
| Traditional | 6.83 ± 0.17av | 6.73 ± 0.26av | 5.66 ± 0.19aw | 5.46 ± 0.11aw | 5.11 ± 0.42ax |
| Gelatin | 7.97 ± 0.16bv | 7.67 ± 0.37bv | 7.44 ± 0.23bv | 7.11 ± 0.30bv | 7.01 ± 0.34bw |
| Alginate | 7.67 ± 0.26bv | 7.33 ± 0.30bv | 7.33 ± 0.33bv | 6.74 ± 0.21bv | 6.44 ± 0.51cv |
| Tenderness | | | | | |
| Traditional | 6.89 ± 0.22av | 6.57 ± 0.55av | 6 ± 0.16aw | 5.75 ± 0.18aw | 5.65 ± 0.32aw |
| Gelatin | 7.83 ± 0.17bv | 7.83 ± 0.11bv | 7.30 ± 0.29bv | 7.00 ± 0.38bw | 6.79 ± 0.20bw |
| Alginate | 7.65 ± 0.15bv | 7.44 ± 0.21cv | 7.13 ± 0.28bw | 6.83 ± 0.39bw | 6.11 ± 0.11cw |
| Overall acceptability | | | | | |
| Traditional | 6.78 ± 0.31av | 6.78 ± 0.11av | 6.61 ± 0.24avw | 6.44 ± 0.11aw | 6.42 ± 0.17aw |
| Gelatin | 7.83 ± 0.27bv | 7.83 ± 0.37bv | 7.54 ± 0.33bw | 7.40 ± 0.19bwx | 7.21 ± 0.21bx |
| Alginate | 7.83 ± 0.17bv | 7.83 ± 0.27bv | 7.30 ± 0.23bvw | 7.00 ± 0.11cvw | 6.73 ± 0.11cw |

*Values represent the mean of three independent replicates ± standard error

[a–c]Values with different superscripts within the same column are significantly ($P < 0.05$) different

[v–x]Values with different superscripts within the same raw are significantly ($P < 0.05$) different

color deterioration in traditional coated pastirma was attributed to the reducing conditions produced in the presence of a high bacterial load which has been avoided by edible coating.

### Sensory quality

The sensory scores (appearance, juiciness, tenderness and overall acceptability) of alginate and gelatin coated pastirma were significantly ($P < 0.05$) higher than those of traditionally coated ones after processing (0-time) and during chilled storage for 4 weeks. Moreover, there was non-significant ($P > 0.05$) difference in sensory scores between gelatin coated and alginate coated pastirma (Table 6). Higher sensory panel scores may be attributed to the delayed respiration rates that have been taken place after application of these edible coatings. The higher sensory scores of edible coated products have been attributed to the reservation of the moisture contents of the product (Antoniewski et al., 2007). Therefore, application of alginate and gelatin coat to pastirma can satisfy both meat consumers and meat producers and can be used by meat industry to produce a higher quality pastirma.

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