Practical Application of Soy Protein Isolates Edible Coating for Improving the Quality Characteristics of Pastirma

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1. Abstract

Packaging fruits and vegetables in edible coatings is frequently used worldwide; however, the use of such innovative technology is somewhat limited in the meat industry. Therefore, the primary goal of the current study was to improve the physicochemical, microbiological, and sensory characteristics of one of the most well-known traditional dry-cured beef products (pastirma). To accomplish the aforementioned goal, 270 deep-frozen semitendinosus muscles were used to prepare pastirma. The traditional coating materials (çemen) were then applied to half of the produced product, while soy protein isolate coating was applied to the other half. All produced pastirma were kept at 5 °C for 4 weeks and investigated weekly for weight loss, pH, thiobarbituric acid reactive substances (TBARS), optical color indexes, proximate chemical analysis, salt and nitrite content, sensory characteristics, and microbial counts. The outstanding findings showed that samples coated with soy protein isolate had better sensory qualities, less moisture loss, a decrease in the overall number of bacteria, and a strong antioxidant impact. In conclusion, meat processors may find that soy protein isolate coating is a useful option for resolving preservation problems that appeared with conventional pastirma coatings.

Key words: Soy protein isolate, Pastirma, Edible coat, Chemical composition.

2. Introduction

Meat and meat products are the most important sources of bioavailable proteins crucial for human life. Providing the required amount of high-quality meat and meat products for consumers is a challenge for all governments. Meat and meat products are highly perishable foods; therefore, meat processors and researchers are continuously seeking valuable and safe technologies for preserving the quality and safety of these products during storage to meet consumer needs and preserve the economies of countries [1]. One of these technologies that is under extensive work is the application of biodegradable edible coating materials.

Biodegradable edible coating materials are usually made from proteins, lipids, polysaccharides, or combinations of those macromolecules together with other chemicals, depending on the objectives of the coating**.** Protein coatings stand out among these alternatives because they are more nutritious and have superior gas barrier characteristics over lipids and polysaccharides [2]. Protein-based biodegradable materials are the most common edible coatings used in the meat industry. Proteins have good coat-

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forming characteristics, satisfactory adherence to hydrophilic surfaces, and acceptable O_2 and CO_2 barrier properties [3]. Both plant and animal sources provide the proteins used for edible coatings. Whey, casein, collagen, and gelatin are the most common animal-based proteins, while soy, maize zein, wheat gluten, pea, rice bran, rice seed, and peanut protein are the plant-based proteins [4]. For a variety of considerations, soy protein isolate (SPI) is considered one of the most desirable raw ingredients for the manufacturing of a fully biodegradable coating. It is used in a variety of applications in different food sectors as a cheap ingredient. Furthermore, soy proteins can produce coatings with superior O_2 barrier characteristics and functional qualities [5].

Pastirma is an intermediate moisture content product that has been dry-cured. Pastirma is typically made with premium, highly expensive whole beef muscles e.g.; silverside, topside, and knuckle. Preservation of pastirma requires the application of a coat on the dry surface of the cured meat and storage at a fairly low temperature. Traditional coating is crucial for maintaining the microbiological, textural, and sensory properties of pastirma [6]. Nevertheless, it may present several challenges that can deteriorate both the quality and wholesomeness of the finished product. One significant issue is the occurrence of cracks and detachment of the coat, which results in exposure of meat to atmospheric conditions that may result in spoilage of the finished product. The incorrect ratio of water content to the dry ingredients of the coating, patchy application of the coating material, and uneven meat drying before coating can all cause this issue. Mold growth and propagation of spore-forming bacteria are other problems that impact the safety of pastirma. The application of soy protein isolate may be a good base for the edible coating of pastirma. Therefore, the main objective of the present work was to investigate the quality characteristics of pastirma coated with soy protein isolate in comparison with traditional coats

3. Materials and Methods

3. 1. Experimental design

The effects of soy protein isolate (SPI) edible coating on physicochemical (weight loss, pH, TBARS, instrumental color, proximate chemical composition, salt, and nitrite content), microbiological and sensory attributes of pastirma were investigated in three experimentally prepared pastirma with three independent replicates. The pastirma was stored at 5 °C for four weeks.

3. 2. Raw materials

Two hundred and seventy imported deep-frozen Brazilian beef topside (about 2.5 kg) were purchased from a local supplier before the elapse of three months from its production date. Soy protein isolate (99% protein) was procured from Sigma-Aldrich (St. Louis, MO, USA). Nubassa Gewürzwerk GmpH (Germany) supplied the cumin, capsicum, fenugreek, and garlic oleoresin. Nitrite, ascorbic acid, and glycerol were obtained from Loba Chemie, Mumbai, India. Moreover, fresh garlic, capsicum powder, fenugreek powder, and sodium chloride were purchased from local marketplaces in Giza, Egypt.

3.3. Preparation of pastirma and application of coatings

Pastirma was processed following the procedure of Abdallah *et al.* [7]. For the production of the traditional pastirma, the topsides were completely thawed at 10°C and trimmed of all visible fats and connective tissue. A curing mixture

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prepared from 99.5% coarse common salt, 0.5% sodium nitrite, and sufficient quantity of cumin powder was used at a rate of 300g/ kg meat for curing the meat at 5 °C for 12 hours. After washing and desalination, the meat was arranged in layers with cotton clothes in between in a hydraulic pressing device and then pressed for 6 hours at 20 bars/inch, followed by 40 bars/inch for another 6 hours. The pressed meat was dried at 50 °C for a couple of hours and then coated with a mixture composed of fenugreek powder, ground fresh garlic, and capsicum powder (2: 1: 0.5 w/w), and hydrated with water to make a sticky paste. Small portions of the prepared paste (not more than 20 % of the meat weight) were evenly distributed as a thin layer of 2 mm thickness over the surface of the pressed meat. For SPI coating pastirma, the meat was cured using the same curing mixture with the addition of a Sufficient quantity of cumin, garlic, capsicum, and fenugreek oleoresin using the same procedure. For coating of cured meat, five grams of SPI were dissolved in 100 ml of distilled water with the addition of glycerol (3.5% w/v) during stirring and adjusting the pH to 10.0 with 0.1 NaOH. The coating solution was heated to 90 °C in a water bath for 30 minutes, followed by cooling to 40 ºC, then filtration through four layers of cheesecloth [8]**.** Dried cured meat was dipped in SPI coating solution for two minutes and hung for half a minute, then dipped again for one minute. Pastirma coated with either traditional or SPI coat was dried in the oven at 50 ºC for a couple of hours and kept in a cool, dry place till the next day, where it was stored at 5 ºC for 4 weeks.

3.4. Analysis of pastirma

At each examination time (after 24 hours and every week), three samples from both trials were analyzed in triplicate for weight loss, pH, TBARS, instrumental color, chemical composition, salt, and nitrite content, microbiological, and sensory attributes.

3.4.1. Physicochemical properties

3.4.1.1. Weight loss

The weight loss % of pastirma was calculated as the loss in weight during storage using the following formula: (Initial weight-weight in the specific time of storage)/initial weight × 100.

3.4.1.2. Hydrogen ion concentration (pH)

Five grams from the meat of the coated pastirma sample were homogenized with 20 ml of distilled water for 10-15 seconds [9], and the pH was measured using a digital pH meter (Lovibond Senso Direct) equipped with a probe-type electrode (Senso Direct Type 330). Three readings for each sample were obtained, and the average was calculated.

3.4.1.3. Thiobarbituric acid reactive substances (TBARS)

The lipid oxidation was evaluated by measuring the TBARS following the method of **Du and Ahn** [10]. Five grams of meat from prepared pastirma were homogenized with 15 mL of deionized distilled water. One milliliter of the homogenate was vortexed with 50 µL of butylated hydroxytoluene (7.2 g/100 g) and 2 mL of thiobarbituric acid (TBA), trichloroacetic acid (TCA) (15 mM TBA, 15 g/100 g TCA), then incubated in a boiling water bath for 15 min to develop the color. Then the samples were cooled in ice for 10 min, vortexed again, and centrifuged for 15 minutes at 2500 xg. The absorbance of the supernatant was measured against a blank containing 1 mL of deionized water and 2 mL of TBA, TCA solution at 531 nm. The TBARS

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value was expressed as mg malonaldehyde/ kg meat.

3.4.1.4. Determination of residual nitrite

Five g prepared pastrima samples were steam-bath heated to 80°C in 300 ml of distilled water for 2 hours, then diluted to 500 ml after cooling to room temperature, and finally filtered. Subsequently, 2.5 ml of sulfanilamide was mixed with 10 ml of the filtrate and allowed to stand for 5 minutes. Then, 2.5 ml of NED (N-(1-naphthyl) ethylenediamine) reagent was added, and the mixture was diluted to 50 ml. The developed color was measured at 540 nm after 15 minutes, using a blank prepared from 45 ml of water, 2.5 ml of sulfanilamide, and 2.5 ml of NED. The residual nitrite was expressed as ppm [11].

3.4.1.5. Determination of salt

One gram of the pastirma sample was mixed with 40 mL of N/10 silver nitrate, then 5 mL of nitric acid was added, and the mixture was gently boiled for 15 minutes. After cooling, 50 mL of distilled water and 2 mL of saturated ferric ammonium sulfate solution were added. The excess silver nitrate was titrated with N/10 ammonium thiocyanate solution using a ferric indicator. The salt concentration was expressed as a percentage according to AOAC [11].

3.4.1.6. Proximate chemical analysis

Moisture, protein, fat, and ash contents of meat from differently coated pastirma were determined for each replicate after processing according to the method of **AOAC [11].** For the determination of moisture contents (g% sample), 10 grams of sample were dried at 100 ºC until two successive constant weights were obtained. Protein percentage was obtained using the micro-Kjeldahl method and a 6.25 conversion factor. Ether extractable lipids (g %) were extracted using petroleum ether and a Soxhlet apparatus. The fat percentage was calculated from the weight loss. Ash was determined by ignition at 500 ºC for 5 hours (g% sample).

3.4.1.7. Instrumental Color Evaluation

The color index of pastirma was assayed by CR 410 Konica Minolta Croma meter (Japan). The L* (lightness), a* (redness), and b* (yellowness) values were obtained using a CIE standard illuminant D65 light source. The color was expressed using the Commission Internationale de l'Eclairage (CIE) L*, a*, and b* color system. The bloom time was 30 min, and the observation angle was 10^{o}. Three measurements were taken from the core of each sample at each time, and the average was recorded [12]**.**

3.4.2. Microbiological examination

Ten grams from the core of the pastirma were homogenized with 90 ml sterile Ringer's solution (Merck, Germany) for two minutes using a lab-blender stomacher (SE 19 UG-model No. 6021, 400) to provide a dilution of 10^{-1}. From the original homogenate, tenfold serial dilutions were prepared [13]**.** For determination of total mesophilic count (TMC), 0.1 ml from each dilution was spread onto the dried surface of double sets of Plate Count Agar plates (CM0463B Oxoid) that were incubated at 35 ºC for 48 hours [14]. Anaerobic spore-forming bacteria were counted using Reinforced Clostridial Agar plates (CM0149, Oxoid) incubated under anaerobic conditions at 35 ºC for 24 hours [15]. Yeasts and mold counts were enumerated on Sabouraud dextrose agar plates (CM0041, Oxoid) incubated at 25 ºC for 5 days [16]. All bacterial counts

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were expressed as colony-forming units per gram (CFU g^{-1}) of the sample.

3.4.3. Sensory investigations

Nine experienced trained panelists carried out the sensory evaluation. Panel members were from the staff members of the Department of Food Hygiene and Control at the Faculty of Veterinary Medicine, Cairo University, Egypt. Four training sessions were held to familiarize the panelists with the pastirma characteristics and the scale to be used. A numerical scale from 1.0 and 9.0 was used, where 1 corresponds to the lowest score for each attribute and 9.0 to the highest. On the scale, 1–3 was regarded as not acceptable, 4–5 fairly acceptable, 6–7 good (acceptable), and 8–9 very good. One slice of pastirma from each sample was evaluated. Panelists were asked to evaluate the samples for appearance, flavor, juiciness, and tenderness and express their general acceptability. The samples were served to panelists in artificial light (incandescent) at ambient temperature in a random order [17]

3.5. Statistical analysis

Statistical data analysis for the three independent replicates was done using SPSS Statistics 17.0 for Windows. Data from coated pastirma samples at each examination time were analyzed using independent T-test to compare the results of the two different coatings. The data of each coat type were compared during storage time using a one-way analysis of variance (ANOVA). Significances were determined using the Least Squares Difference test (LSD) procedure. Differences were considered significant at the $P < 0.05$ level.

4. Results

4.1. Physicochemical properties and microbiological examination

4.1.1. Weight loss

The weight loss of pastirma coated with SPI was significantly ($P < 0.05$) lower than that coated with the traditional coating with SPI, showing significantly ($P < 0.05$) lower water loss throughout the storage period (Table 1).

4.1.2. Hydrogen ion concentration, TBARS, salt, and residual nitrite

The results of deterioration indexes (pH and TBARS) showed that pastirma coated with SPI had significantly ($P < 0.05$) lower values for both in comparison with those of traditionally coated ones after processing and during storage time (Table 2). Coating pastirma with SPI-coating significantly reduced salt content ($P < 0.05$) compared to traditionally coated pastirma at zero time and during chilled storage (Table 2). During storage, the salt concentration gradually increased. Residual nitrite levels (ppm) in SPI-coated pastirma were significantly lower ($P < 0.05$) than those in traditionally coated pastirma (Table 2). Furthermore, there was a significant reduction ($P < 0.05$) in residual nitrite levels during storage for all types of coated pastirma.

4.1.3. Proximate chemical analysis

Coating of pastirma with SPI resulted in a significant ($P<0.05$) increase in moisture and protein content and a substantial decrease in both fat and ash after processing and during chilled storage for 4 weeks when compared with the traditionally coated one (Table 3).

4.1.4. Instrumental color

SPI-edible coating resulted in a significant ($P < 0.05$) reduction in lightness (L*) values, a significant ($P <$

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0.05) elevation in redness (a*) and brownness (b*) values when compared with those of the traditional coated one at 0-time and during the storage period. Storage of coated pastirma at 5 ºC for 4 weeks with both coated materials resulted in a significant ($P < 0.05$) decrease of L* and a* values and a significant ($P < 0.05$) increase of b* values (Table 4).

4.2. Microbiological examination

The counts of aerobic mesophilic and anaerobic bacteria, as well as yeast and molds of SPI-coated pastirma, were significantly ($P<0.05$) lower than those of traditionally coated ones after processing (0-time) and during storage (Table 5), i.e., SPI coating exhibited effective antibacterial properties in dry-cured meat products.

4.3. Sensory analysis

The sensory panel scores for color, juiciness, tenderness, and overall acceptability of SPI-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 (Table 6).

5. Discussion

5.1. Physicochemical properties and microbiological examination

5.1.1 Weight loss

The lower weight loss of SPI-coated pastirma may be due to variations in the water permeability of the coating materials. In general, SPI has poor moisture barrier properties [18] due to its hydrophilic nature [19]**.** However, thermal processing during the preparation of SPI can enhance its barrier characteristics due to the denaturation of the protein molecules, loss of the original protein structure, and the creation of physical intermolecular connections among the protein entities [20].

5.1.2. Hydrogen ion concentration, TBARS, salt, and residual nitrite

The TBARS values of traditionally coated pastirma exceeded the allowable limit (0.5-1 mg/kg, Warriss, 2000) by the 2nd week of storage; however, those of SPI-coated samples remained below the permissible limit until the end of the storage periods. These results suggested that SPI-edible coating delayed lipid oxidation, which substantiated the antioxidant effect of SPI reported by Zubair and Ullah [5] in beef model systems. The antioxidant effect of SPI coating can be explained by either the radical scavenging effect of its amino acid content, e.g., cysteine, tyrosine, tryptophan, and histidine [21], and/or its low O_2 permeability [22].

During storage, the salt concentration gradually increased, which can be attributed to the weight loss, which primarily consisted of water [23]. Residual nitrite levels (ppm) in SPI-coated pastirma were significantly lower ($P < 0.05$) than those in traditionally coated pastirma (Table 2). Furthermore, there was a significant reduction ($P < 0.05$) in residual nitrite levels during storage for all types of coated pastirma. The higher residual nitrite content in traditionally coated pastirma may be due to the higher weight loss.

5.1.3. Proximate chemical analysis

The variation in chemical composition between traditionally coated and SPI-coated pastirma is a good indication of the variation in permeability of the coating materials. It has been reported that the SPI coat forms a semipermeable coating that can decrease water migration and retard moisture loss from food products [20].

5.1.4. Instrumental color

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The higher a* and lower b* values obtained in SPI-coated pastirma may be explained by the SPI's gas barrier and antioxidant properties, which prevent meat oxidation [21,22]. This delay in color deterioration follows the delay in lipid oxidation measured by TBARS values.

5.2.Microbiological examination

The antibacterial activities of SPI have been explained by its isoflavones content (especially genistein) [24, 25] and the low O_2 permeability [22] that reduces the entrance of oxygen to the meat, which may constitute an unfavorable condition for microbial growth. These observations were not in agreement with Emiroğlu et al. [26], who found that SPI-based edible films incorporated with oregano or thyme essential oils did not have significant effects on TMC when applied to beef patties.

5.3.Sensory analysis

The higher color score of SPI-coated pastirma may result from the low O_2 permeability [22] and the ability of radical scavenging activity by some amino acids present in soy protein [21], which prevents color deterioration. It has been noticed that the higher juiciness and tenderness scores of SPI-coated pastirma may be explained by the greater moisture barrier characteristics [20].

6. Conclusions

The SPI-based edible coating was effective in improving sensory attributes, lowering moisture loss, and antibacterial activity, and delaying lipid oxidation and color deterioration, thereby extending the shelf life of pastirma. Therefore, results confirm the potential of soy protein coating material that can improve the quality of pastirma and can satisfy both consumers and meat producers but needs some modifications to produce a higher quality pastirma

Conflict of interest: Nothing to declare

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Table (1): weight loss of traditional and SPI-coated pastirma during storage at 5 ºC for 4 weeks.

	Weight loss * (%)			
	1st week	**2nd week**	**3rd week**	**4th week**
Traditional	4.63±0.12^{a,A}	8.77±0.32^{a,B}	11.44±0.21^{a,C}	14.91±0.11^{a,}
Soy	3.36±0.35^{b,A}	6.55±0.75^{b,B}	8.64±0.94^{b,B}	9.43±0.89^{b,C}

*Values represent the mean of three independent replicates± standard error
$^{a–b}$ Values with different superscripts within the same column are significantly (P <0.05) different.
$^{A-C}$ Values with different superscripts within the same row are significantly (P <0.05) different**.**

Table (2): Hydrogen ion concentration, TBARS, salt, and residual nitrite of traditional and SPI-coated pastirma at zero time and during storage at 5 ºC for 4 weeks.

	pH				
	Zero	**1st week**	**2nd week**	**3rd week**	**4th week**
Traditional	5.42±0.02^{a,A}	5.64±0.01^{a,B}	5.67±0.01^{a,B}	5.78±0.04^{a,C}	5.99±002^{a,D}
Soy	5.52±0.02^{b,A}	5.61±0.05^{a,AB}	5.63±0.05^{ab,AB}	5.76±0.12^{ab,B}	5.70±0.09^{c,B}
	TBA				
Traditional	0.81±0.01^{a,A}	0.84±0.12^{a,A}	0.98±0.07^{a,A}	0.98±0.09^{a,A}	1.21±0.07^{a,B}
Soy	0.52±0.08^{c,A}	0.66±0.03^{d,B}	0.68±0.02^{d,B}	0.77±0.03^{b,BC}	0.82±0.06^{b,C}
	Salt				
Control	7.81±0.02^{ab,A}	7.93±0.02^{ab,B}	8.00±0.02^{a,C}	8.00±0.02^{a,C}	8.00±0.90^{a,C}
Soy	7.74±0.05^{bc,A}	7.89±0.07^{a,B}	7.92±0.15$^{a.B}$	7.93±0.02^{b,B}	8.03±0.67^{b,C}
	Nitrite				
Control	57.63±2.76^{a,A}	54.91±2.74^{a,A}	23.18±2.31^{a,B}	23.18±2.31^{ab,B}	19.38±1.32^{ab,B}
Soy	53.58±1.71^{ab,A}	39.52±1.66^{d,B}	13.30±2.01^{b,C}	11.02±1.01^{b,C}	9.88±1.38^{d,C}

*Values represent the mean of three independent replicates± standard error
$^{a–b}$ Values with different superscripts within the same column are significantly (P <0.05) different.
$^{A-D}$ Values with different superscripts within the same row are significantly (P <0.05) different.

Table (3): proximate chemical analysis of traditional and SPI-coated pastirma at zero time and during storage at 5 ºC for 4 weeks.

	Zero	1st week	2nd week	3rd week	4th week
Moisture					
Traditional	59.08±0.18^{a,A}	58.93±0.22^{a,A}	57.05±0.59^{ac,B}	50.62±0.36^{a,C}	46.25±0.11^{a,D}
Soy	60.62±0.21^{b,A}	59.30±0.68^{a,AB}	58.63±0.31^{b,B}	52.35±0.85^{b,C}	48.67±0.28^{b,D}
Protein					
Traditional	26.46±0.09^{a,A}	26.64±0.20^{a,A}	27.35±0.08^{a,A}	30.38±0.02^{a,B}	32.66±0.70^{a,C}
Soy	26.10±0.34^{a,A}	26.54±0.18^{a,AB}	27.07±0.20^{a,B}	32.62±0.16^{c,C}	35.22±0.51^{bc,D}
Fat					
Traditional	4.25±0.18^{a,A}	4.42±0.17^{ac,A}	4.80±0.31^{a,A}	6.59±0.27^{a,B}	6.67±0.09^{a,B}
Soy	3.52±0.07^{b,A}	3.57±0.15^{ab,A}	4.26±0.29^{a,B}	5.10±0.30^{c,C}	5.17±0.10^{c,C}
Ash					
Traditional	9.71±0.10^{a,A}	9.94±0.59^{abc,B}	9.98±0.12^{a,B}	11.15±0.26^{a,B}	11.84±0.22^{ab,B}
Soy	8.62±0.11^{c,A}	9.83±0.07^{bc,A}	9.92±0.16^{a,A}	10.15±0.41^{b,B}	10.85±0.26^{c,B}

*Values represent the mean of three independent replicates± standard error
$^{a–b}$ Values with different superscripts within the same column are significantly (P <0.05) different.
$^{A-D}$ Values with different superscripts within the same row are significantly (P <0.05) different.

Table (4): Instrumental color of traditional and SPI-coated pastirma at zero time and during storage at 5 ºC for 4 weeks.

	Zero	1st week	2nd week	3rd week	4th week
Lightness (L*)					
Traditional	37.88±0.35^{a,A}	35.31±0.42^{a,B}	34.59±0.20^{a,C}	33.47±0.60^{ad,C}	31.497±0.23^{a,D}
Soy	36.90±0.39^{ab,A}	34.38±0.85^{bc,B}	32.65±0.15^{b,C}	31.237±0.15^{b,D}	30.32±0.14^{c,E}
Redness (a*)					
Traditional	16.13±0.11^{a,A}	12.90±0.17^{a,B}	12.58±0.16^{a,B}	11.60±0.14^{a,C}	11.53±0.43^{a,C}
Soy	16.17±0.31^{c,A}	14.95±0.96^{c,A}	14.17±0.40^{c,A}	12.90±0.17^{c,B}	12.90±0.59^{b,B}
Brownness (b*)					
Traditional	4.98±0.72^{a,A}	5.70±0.45^{ab,B}	6.37±0.11^{a,C}	6.71±0.86^{a,D}	8.44±0.12^{a,E}
Soy	5.70±0.10^{b,A}	5.89±0.10^{b,A}	7.37±0.90^{a,B}	8.00±0.25^{b,C}	8.69±0.36^{a,D}

*Values represent the mean of three independent replicates± standard error
$^{a–b}$ Values with different superscripts within the same column are significantly (P <0.05) different.
$^{A-E}$ Values with different superscripts within the same row are significantly (P <0.05) different.

Table (5): Microbiological examination of traditional and SPI-coated pastirma at zero time and during storage at 5 ºC for 4 weeks.

	Zero	1st week	2nd week	3rd week	4th week
TMC (CFU)					
Traditional	4.11±0.60^{a,A}	4.87±0.27^{a,B}	5.02±0.38^{a,BC}	5.82±0.28^{a,C}	5.91±0.03^{a,C}
Soy	3.08±0.15^{b,A}	4.12±0.03^{b,B}	4.37±0.67^{b,B}	4.42±0.35^{b,BC}	4.95±0.49^{b,C}
Anaerobes					
Traditional	3.50±0.22^{a,A}	4.06±0.36^{a,B}	5.03±0.47^{a,C}	5.33±0.19^{a,CD}	5.96±0.15^{a,D}
Soy	<2.00±0.00^{b,A}	<2.00±0.00^{b,A}	2.55±0.67^{b,B}	3.17±0.23^{b,C}	3.18±0.12^{b,C}
Yeast					
Traditional	3.50±0.21^{a,A}	3.96±0.38^{a,A}	4.6±0.55^{a,B}	5.08±0.27^{a,BC}	5.77±0.50^{a,C}
Soy	<2.00±0.00^{b,A}	<2.00±0.00^{b,A}	<2.00±0.00^{b,A}	<2.00±0.00^{b,A}	<2.00±0.00^{b,A}
Mold					
Traditional	3.90±0.20^{a,A}	4.60±0.48^{a,B}	4.90±0.55^{a,B}	5.31±0.27^{a,C}	5.77±0.50^{a,C}
Soy	<2.00±0.00^{b,A}	<2.00±0.00^{b,A}	<2.00±0.00^{b,A}	2.55±0.11^{b,B}	2.89±0.22^{b,B}

*Values represent the mean of three independent replicates± standard error
$^{a–b}$ Values with different superscripts within the same column are significantly (P <0.05) different.
$^{A-B}$ Values with different superscripts within the same row are significantly (P <0.05) different.

Table (6): sensory panel score of coat and meat of traditional and SPI-coated pastirma at zero time and during storage at 5 ºC for 4 weeks.

	Zero	1st week	2nd week	3rd week	4th week
Color					
Control	6.33±0.33^{a,A}	6.33±0.23^{a,A}	5.56±0.11^{a,B}	5.11±0.11^{a,B}	5.00±0.19^{a,B}
Soy	8.00±0.09^{b,A}	8.00±0.23^{b,A}	7.44±0.11^{bc,B}	7.44±0.11^{b,B}	6.67±0.10^{c,C}
Flavor					
Control	6.83±0.17^{a,A}	6.83±0.26^{a,A}	5.67±0.19^{a,B}	5.56±0.11^{a,BC}	5.11±0.42^{a,C}
Soy	8.00±0.34^{d,A}	7.78±0.41^{b,AB}	7.67±0.17^{bc,AB}	7.67±0.28^{b,AB}	7.44±0.26^{b,B}
juiciness					
Control	6.89±0.22^{a,A}	6.67±0.55^{a,A}	6.11±0.16^{a,AB}	5.78±0.18^{a,B}	5.67±0.32^{a,B}
Soy	8.08±0.25^{c,A}	8.00±0.21^{b,AB}	7.56±0.11^{c,BC}	7.45±0.37^{b,C}	7.11±0.28^{c,C}
Tenderness					
Control	8.00±0.14^{a,A}	7.56±0.30^{ac,AB}	7.45±0.22^{abc,B}	7.11±0.26^{a,BC}	6.89±0.11^{a,C}
Soy	8.33±0.33^{bd,A}	7.78±0.25^{abd,B}	7.22±0.19^{b,C}	7.22±0.29^{a,C}	7.11±0.24^{ab,C}
Overall acceptability					
Control	6.78±0.31^{a,A}	6.78±0.11^{a,A}	6.61±0.24^{a,A}	6.44±0.11^{a,A}	6.42±0.17^{a,A}
Soy	8.11±0.21^{d,A}	7.75±0.12^{bd,AB}	7.45±0.34^{bc,BC}	7.39±0.25^{bc,BC}	7.00±0.17^{b,C}

*Values represent the mean of three independent replicates± standard error
$^{a–d}$ Values with different superscripts within the same column are significantly (P <0.05) different.
$^{A-C}$ Values with different superscripts within the same row are significantly (P <0.05) different.