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Active alginate-based edible coating containing cinnamon (*Cinnamomum zeylanicum*) and marjoram (*Origanum majorana* L.) essential oils on quality of Wagyu hamburgers

Cobertura comestível ativa à base de alginato contendo óleos essenciais de canela (*Cinnamomum zeylanicum*) e manjerona (*Origanum majorana* L.) na qualidade de hambúrguer de Wagyu

Cobertura comestible activa a base de alginato que contiene aceites esenciales de canela (*Cinnamomum zeylanicum*) y mejorana (*Origanum majorana* L.) em la calidad de hamburguesa de Wagyu

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Abstract

This study evaluated the use of an edible coating alginate-based with essential oil (cinnamon and marjoram) on the quality of Wagyu hamburgers (pH, weight loss, cooking loss, texture, color, lipid oxidation and antioxidant activity) during 7 days of display. Microscopy, FTIR and acceptability were also evaluated. Four treatments were evaluated: CON –hamburger without edible coating; ECO –with edible coating; CIN –with edible coating containing 0.1% of cinnamon essential oil; MAJ –with edible coating containing 0.1% of marjoram essential oil. pH of the samples was maintained throughout the storage time ($p>0.05$). Coatings decreased water and color losses, and shear force in relation to CON. The results indicated that CIN presented the highest antioxidant activity ($p<0.001$). Malonaldehyde value increased for all samples of during storage ($p<0.001$), being more accentuated for CON. The CIN presented best results in the majority of the analyzes, which indicates that the use of the cinnamon essential oil in coating can increase/maintain the quality of hamburgers during display.

Keywords: Antioxidant activity; Lipid oxidation; Color; Scanning electron microscope; Spectroscopy; FTIR.

Resumo

Este estudo avaliou o efeito de uma cobertura comestível à base de alginato com óleo essencial (canela e manjerona) na qualidade de hambúrgueres de Wagyu (pH, perda de peso, perda por cozimento, textura, cor, oxidação lipídica e atividade antioxidante) durante 7 dias de exposição. Microscopia, FTIR e aceitabilidade também foram avaliados. Quatro tratamentos foram avaliados: CON - hambúrguer sem cobertura comestível; ECO - com cobertura comestível; CIN - com cobertura comestível contendo 0,1% de óleo essencial de canela; MAJ - com cobertura comestível contendo 0,1% de óleo essencial de manjerona. O pH das amostras foi mantido ao longo do tempo de armazenamento ($p > 0,05$). As coberturas diminuíram as perdas de água e cor e a força de cisalhamento em relação ao CON. Os resultados indicaram que CIN apresentou a maior atividade antioxidante ($p < 0,001$). O valor de malonaldeído aumentou para todas as amostras durante o armazenamento ($p < 0,001$), sendo mais acentuado para CON. O CIN apresentou os melhores resultados na maioria das análises, o que indica que o uso do óleo essencial de canela no revestimento pode aumentar/manter a qualidade dos hambúrgueres durante a exposição.

Palavras-chave: Atividade antioxidante; Oxidação lipídica; Cor; Microscopia eletrônica de varredura; Espectroscopia; FTIR

Resumen

Este estudio evaluó el efecto de una cobertura de alginato comestible con aceite esencial (canela y mejorana) sobre la calidad de las hamburguesas de Wagyu (pH, pérdida de peso, pérdida de cocción, textura, color, oxidación de lípidos y actividad antioxidante) durante 7 días de exposición. También se evaluaron microscopía, FTIR y aceptabilidad. Se evaluaron cuatro tratamientos: CON - hamburguesa sin cobertura comestible; ECO - con cobertura comestible; CIN - con cobertura comestible que contiene 0,1% de aceite esencial de canela; MAJ - con cobertura comestible que contiene 0,1% de aceite esencial de mejorana. El pH de las muestras se mantuvo durante el período de almacenamiento ($p > 0,05$). Las coberturas disminuyeron las pérdidas de agua y color y la fuerza de corte en relación con el CON. Los resultados indicaron que CIN tenía la mayor actividad antioxidante ($p < 0,001$). El valor de malonaldehído aumentó para todas las muestras durante el almacenamiento ($p < 0,001$), siendo más pronunciado para CON. El CIN presentó los mejores resultados en la mayoría de los análisis, lo que indica que el uso de aceite esencial de canela en el recubrimiento puede incrementar/mantener la calidad de las hamburguesas durante la exposición.

Palabras clave: Actividad antioxidante; Oxidación de lípidos; Color; Microscopía electrónica de barrido; Espectroscopia; FTIR.

1. Introduction

Gourmet products have been gaining increased popularity in the world of gastronomy. In accordance with this trend, Wagyu beef has become popular in the beef market, and its most noticeable characteristic is the intense marbling. Nonetheless, in addition to the peculiar appearance of Wagyu beef, its highly developed production system makes it a high-quality product (Motoyama, Sasaki, & Watanabe, 2016).

Meat and meat co-products with a high fat content are often affected by lipid oxidation, which occurs naturally. However, poor handling and display can accelerate oxidation (Andrés, Petrón, Adámez, López, & Timón, 2017). Lipid oxidation is the main cause of meat and meat products quality loss, resulting in undesirable compounds that lead to changes in the sensory properties such as odor, flavor, and texture, and nutritional value, thus determining the product shelf life (Ortuño, Serrano, Jordán, & Bañón, 2014). Oxidative processes are worst in processed products because they have a larger surface area exposed to oxygen, anticipating lipid oxidation and altering the quality of the product (Cleveland et al., 2014; Embuscado, 2015; Özvural, Huang, & Chikindas, 2016).

In order to reduce oxidative process, synthetic antioxidants are used in the food industry (Bera, Lahiri, & Nag, 2006). However, due to the increasing consumer demand for safer and healthier food, synthetic antioxidants have been replaced by natural ones in animals' diets and meat coproducts (Kempinski et al., 2017; Monteschio et al., 2017; Rivaroli et al., 2016). Among the natural products, essential oils have shown remarkable conservators properties, since they are known for present antioxidant, antimicrobial and antifungal activity, being biodegradable, renewable and eco-friendly (Jayasena & Jo, 2013). According to some researchers, cinnamon and marjoram essential oils are the oils that most possess bioactive components with antioxidant potential (Biondo et al., 2017; Ghaderi-Ghahfarokhi, Barzegar, Sahari, Gavlighi, & Gardini, 2017), in this way, they were chosen in the present study. These essential oils can be used directly in the formulation of foods or added to the packaging/edible coatings. Despite the beneficial properties, the use of essential oils is limited due to their strong flavor, hindering their use in high concentrations (Cestari et al., 2015).

Edible coatings have been used to improve the oxygen and moisture barriers, mechanical properties, microbial and antioxidant protection, and prolong the shelf life of various food products (Galus & Kadzińska, 2015; Vital et al., 2016). Thus, the coatings can act as a means for incorporation of the oils, so their addition may minimize deterioration during display increasing the shelf life of the product (Vital et al., 2016).

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In view of the increasing knowledge of the exceptional quality of Wagyu beef, the objective of this study was verified the efficacy of edible coating containing cinnamon and marjoram essential oil on the quality maintenance of Wagyu hamburgers during display.

2. Material and Methods

2.1. Material

1,1-Diphenyl-2-picry-hydrazil (DPPH), 2,2-azinobis-3-ethylbenzotiazoline-6-sulfonic acid (ABTS), Gallic acid, potassium persulfate, sodium carbonate, Trichloroacetic acid (TCA), Hydrochloric acid and 1,3,3- Tetramethoxypropane were obtained from Sigma-Aldrich (USA). Thiobarbituric acid (TBA-Alfa Aesar®) was obtained from A Johnson Matthey Company (USA). Sodium alginate was from Dinamica (Brazil), calcium chloride from Anidrol (Brazil), Cinnamon and marjoram essential oil was from Ferquima® (Brazil).

2.2. Meat samples

The meat was from a single Wagyu animal (bull), supplied by Noma do Brasil S/A company, Maringá, Paraná, Brazil. After slaughter, the carcasses were chilled at 4 oC for 24 h. Then, the M. semimenbranosus muscle was used, transported to the laboratory, vacuum-packaged and frozen intact at -18 oC, until analysis (less than 1 week).

2.3. Preparation of the hamburgers

The beef was thawed (4 °C/24h) and ground in an industrial grinder. Subsequently, the ground beef was homogenized, separated in portions of 30 g and shaped to make hamburgers with approximately 2 cm thick with 10 cm in diameter. Finally, the hamburgers were distributed randomly for treatment appliance (with or without coating) and stored for future analysis.

2.4. Coating solutions and treatments

2.4.1. Coating preparation

Alginate coating was prepared according Vital et al. (2016). Sodium alginate (2%) was dissolved in distilled water on the magnetic stirrer (70 °C/30 min), and after the solution was chilled to room temperature (25 ºC). For active edible coating, 0.1% cinnamon and marjoram essential oil were added to the alginate solution (25 °C/15 min under magnetic stirring). A calcium chloride solution at 2% (w/v) was used as a complexing medium. Hamburgers were submerged in alginate solution (1 min), rested (1 min), submerged in the calcium solution (1 min), and rested again (1 min). After covered, the hamburgers were packed in plastic bag and stored in an illuminated display (2 °C, fluorescent lamp, 1200 lux, 12 h/day) simulating typical Brazilian market conditions. The treatments were defined as: CON – hamburger without edible coating; ECO – hamburger with edible coating; CIN – hamburger with edible coating containing 0.1% of cinnamon essential oil (with 78.84% of 3-allyl-2-methoxyphenol and 4.70% of caryophyllene as major components); MAJ – hamburger with edible coating containing 0.1% of marjoram essential oil (with 26.24% of (R)-(-)-p-menth-1-en-4-ol, 16.54% of gama-terpinene, 13.22% of o-cymene and 11.93% of beta-phellandrene). Samples were randomly removed at 1, 4 and 7 days of display, for analysis.

2.5. pH

The pH was measured using a pH meter (Hanna – HI99163, Romania – Europe) equipped with insertion pH electrode.

2.6. Cooking and weight losses

Cooking loss evaluation followed the methodology described by Carvalho et al. (2017). Hamburgers were previously weighed and wrapped in aluminum foil. Each sample was grilled on a preheated electric grill (Grill Philco Jumbo Inox, Philco SA, Brasil) at 200 °C until the internal temperature reaches 72 °C. Right after, samples were cooled up to room temperature (25 °C) and then weighed again. Cooking losses were calculated by Eq 1:

$$\text{Cooking loss } \% = (\text{initial weight-cooked weight} / \text{initial weight}) * 100 \qquad (1)$$

The weight loss was verified according to Honikel (1998), during the display days. Samples were weighed and stored under refrigeration at 4 °C, and after the stipulated display period, samples were weighed again. The amount of mass losses during display is expressed as a percentage (Eq.2).

$$\text{Weight loss } \% = (\text{initial weight-final weight} / \text{initial weight}) * 100 \qquad (2)$$

2.7. Texture

Shear force was measured with a texturometer (TAXT Plus Texture Technologies Corp., Godalming, Surrey, Reino Unido), equipped with a Warner-Bratzler blade. A speed of 5.0 mm.s^{-1} was used and the peaks expressed in N. The samples were cut into rectangular pieces (1 cm2).

2.8. Color

The color was evaluated using a portable chromameter (Minolta CR400, 10° view angle, D65 illuminant). Color was determined based on the CIELab system.

2.9. Antioxidant activity

Antioxidant activity analysis of the hamburgers was performed on 1, 4 and 7 days, after extraction (1:1 w/v with methanol). Extracts were obtained by homogenization in ultra-Turrax (IKA®-T10, EUA) followed by centrifugation (4.000 rpm /15 min) and filtration in filter paper (weight - 80 g/m2, thickness - 205 µm, pores- 14 µm). Antioxidant activity was evaluated using 2,2-diphenyl-1-picrylhydrazyl (DDPH) and 2,2'-azino-bis-3-ethylbenzothiazoline-6-sulphonic acid (ABTS).

The ABTS assay was executed according to Re et al. (1999). The radical scavenging activity (%) was measured at 734 nm and calculated as Eq. 1:

$$\text{ABTS radical scavenging activity (\%)} = \left(1-(A_{sample\ t}/A_{sample\ t=0})\right)*100 \qquad (1)$$

where: A sample t = 0: sample absorbance at time zero; A sample t: sample absorbance at 6 min.

DPPH scavenging activity was performed according to Li, Hydamaka, Lowry, and Beta (2009), measured at 515 nm and calculated as follows Eq. 2:

$$\text{DPPH radical scavenging activity (\%)} = \left(1- (A_{sample\ t} /A_{sample\ t=0}\right) * 100 \qquad (2)$$

where: A sample t = 0: sample absorbance at time zero; A sample t: sample absorbance at 30 min.

2.10. Lipid oxidation

Hamburger (5 g) was mixed with a solution of TCA containing 7.5% TCA, 0.1% EDTA and 0.1% gallic acid (10 mL). Then, homogenized with an Turrax, centrifuged at 4 °C for 15 min and 4.000 rpm. The supernatant used for analyses, was filtered and mixed with the reagent of TBARS, with 1% thiobarbituric acid, 562.5 µM, HCl, 15% TCA (1:1 v/v) (Souza et al., 2011). Subsequently, the mixture was boiled (100 °C) during 15 min, chilled, and absorbance measured at 532 nm. The concentrations were determined by an malonaldehyde (MDA) standard curve (using 1,3,3-tetramethoxypropane), ranging from 0 to 60 mM. Results were expressed as mg MDA kg-1 of hamburger.

2.11. Spectroscopy – FTIR

FTIR analysis of the coatings was performed using a spectrophotometer Spectrum 100 (PerkinElmer). Samples were mixed with KBr (Sigma-Aldrich) (1:100 w/w), and FTIR spectra were recorded in the range 4000-400 cm-1 in absorbance mode.

2.12. Consumer analyses

Consumer test was performed in an adequately room at the Universidade Estadual d e Maringá (Brazil). 100 consumers were randomly selected. Ten sessions were carried out with different consumers. Four samples were evaluated by each consumer. Consumers were requested evaluate each sample related to tenderness, odor, flavor and overall acceptability, using a 9-point scale (1 = dislike extremely to 9 = like extremely). The sensory analysis was approved by the Committee on Ethics CAAE 63777416.3.0000.010.

2.13. Statistical analyses

All experiments were performed with four treatments in triplicate two times. The analysis of variance using the general linear model (GLM) - SPSS (v.15.0) (IBM SPSS Statistics, SPSS Inc., Chicago, EUA) for Windows was used. Means and standard deviation were calculated for each variable. The coating and storage were considered fixed factors in a factorial design. Differences between means were evaluated by Tukey test ($p < 0.05$).

Related to consumer test, the coating was considered a fixed factor and the consumer a random factor (ten replicates per treatment). Differences between means were evaluated by Tukey's test ($p<0.05$).

3. Results e discussion

3.1. pH, Weight and cooking losses

The pH, weight loss, cooking loss and shear force of wagyu hamburger during display are presented in Table 1. Interactions between the treatment and the storage time were not observed for these parameters (p>0.05).

Table 1. pH, weight and cooking losses, color, lipid oxidation and antioxidant activity of Wagyu hamburger during 7 days of display.

	Treatments				Days			SEM[5]	P_{trat}[6]	$P_{display}$[7]	P_{txd}[8]
	CON[1]	ECO[2]	CIN[3]	MAJ[4]	1	3	7				
pH	5,65	5,66	5,67	5,64	5,64	5,65	5,67	0,006	0,401	0,141	0,845
Weight loss	2,88^{A}	1,21^{B}	0,78^{C}	0,99^{BC}	0,91^{c}	1,39^{b}	2,09^{a}	0,167	0,000	0,000	0,562
Cooking loss	28,49	25,36	24,71	25,21	27,74	25,48	24,61	0,567	0,081	0,070	0,963
Texture	10,88^{A}	10,56^{AB}	8,25^{B}	9,03^{AB}	13,07^{a}	8,49^{b}	7,49^{b}	0,601	0,021	0,000	0,802
L*	34,56^{A}	29,41^{B}	26,88^{C}	27,41^{C}	33,22^{a}	28,50^{b}	26,98^{c}	0,522	0,000	0,000	0,550
a*	11,86^{D}	14,30^{C}	18,98^{A}	16,58^{B}	16,58^{a}	15,62^{a}	14,10^{b}	0,406	0,000	0,000	0,000
b*	12,53^{C}	14,10B	13,57^{BC}	15,64^{A}	16,11^{a}	13,72^{b}	12,05^{c}	0,295	0,000	0,000	0,000
DPPH	24,30^{BC}	21,2^{C}	55,9^{A}	27,3^{B}	35,88^{a}	32,74^{b}	28,06^{c}	2,440	0,000	0,000	0,451
ABTS	23,78^{C}	26,92^{B}	45,02^{A}	29,20^{B}	35,09^{a}	31,22^{b}	27,37^{c}	1,511	0,000	0,000	0,435
TBARS	2,09^{A}	1,24^{B}	0,70^{D}	1,05^{C}	0,62^{c}	1,44^{b}	1,76^{a}	0,131	0,000	0,000	0,031

Means of treatments with different small letters in the same line are significantly different (p < 0.05). Means of storage with different uppercase letters in the same line are significantly different (p < 0.05). [1]CON – hamburger without edible coating; [2]ECO – hamburger with edible coating; [3]CIN – hamburger with edible coating containing 0.1% of cinnamon essential oil; [4]MAJ – hamburger with edible coating containing 0.1% of marjoram essential oil. [5]SEM: Standard error of means. [6]Ptrat: effect of treatment; [7]Pdays: effect of days; [8]Ptxd: interaction between treatments and days of storage; [9]TBARS: thiobarbituric acid reactive (mg MDA/ kg of meat); [10]DPPH: DPPH radical scavenging (%); [11]ABTS: ABTS radical scavenging (%). Source: authors.

Regarding the pH, the treatment and the display time did not affect this parameter (p>0.05). In relation to weight loss, the edible coating significantly decreased (p< 0.001) the losses and it progressively increased during storage (p<0.001). The coating with cinnamon was more efficient in reduce the weight loss, followed by coating with marjoram and the coating without oil. Vital et al. (2016) observed that the alginate edible coating with essential oils addition contributed to protect the meat against water losses resulting in a juicier and tender beef.

The cooking loss values was not affected ($p > 0.05$) by the edible coating and the display time.

3.2. Texture

The shear force decreased ($p<0.01$) with display period for the hamburgers, and the control and ECO groups, had the highest shear force (Table 1). This fact may be associated with loss of water and oxidative processes during display. The presence of water in the product system provides a juicier and softer product. Moreover, lower oxygen concentrations in contact with essential oils can reduce lipid and protein oxidation levels, and decrease the action of proteolytic enzymes (Vital et al., 2017).

3.3. Color

Color (L*, a*, and b*) values are provided in Table 1. The L* value (lightness) was higher ($P < 0.001$) for CON and ECO. Thus, coating with essential oil reduced L* value, making the hamburger darker. This fact could be associated with oxidizing conditions, higher in samples without essential oil, which leads to changes in the meat structure, increasing the L* value (MacDougall, 1982).

The a* value (redness) of treatments were significant different ($P < 0.001$) between treatments, with higher values for CIN and MAJ treatments, followed by ECO and CON treatment (Table 1), and these values reduced with display time ($p<0.05$). For a*, an interaction between treatment and display time was observed and this was demonstrated on Figure 1. The CON presented a loss of a* value during storage, while the other treatments with coating maintained the red color of hamburger.

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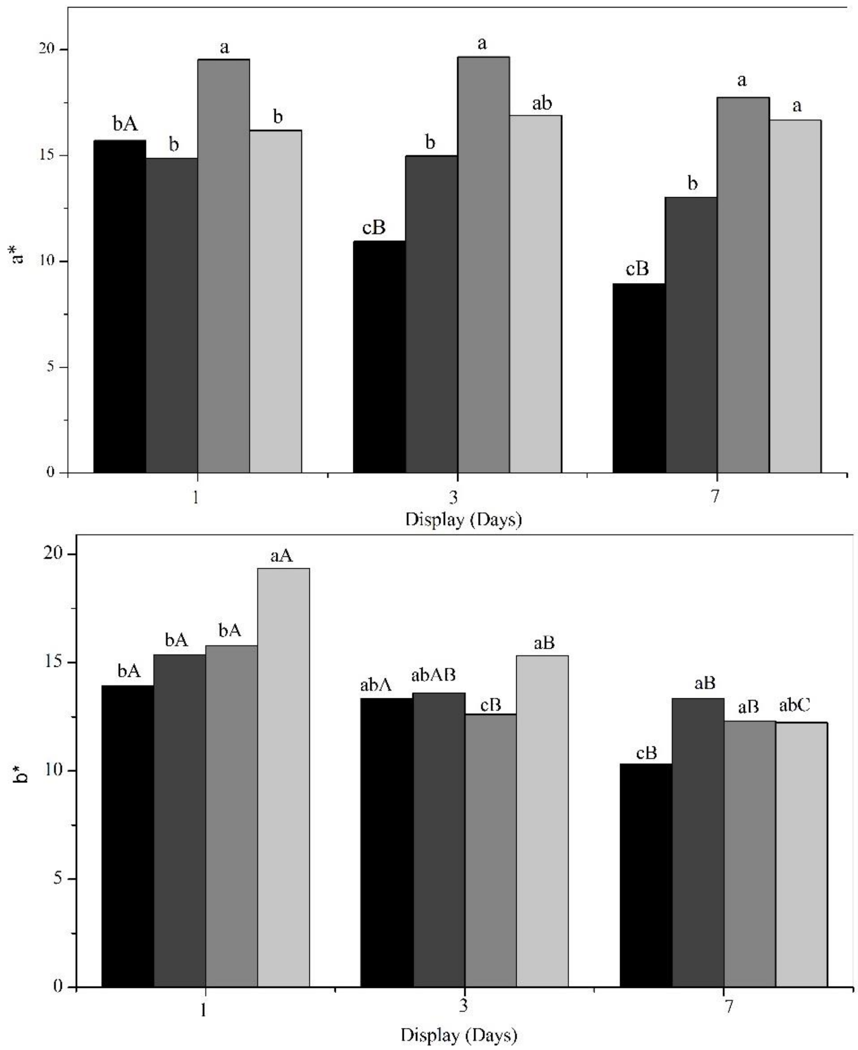
Figure 1. Interaction between treatments and storage time on color parameters (a*and b* values) of Wagyu Burger. (CON – hamburger without edible coating; ECO – hamburger with edible coating; CIN – hamburger with edible coating containing 0.1% of cinnamon essential oil; MAJ – hamburger with edible coating containing 0.1% of marjoram essential oil)..



Source: Authors.

In relation to b* values (yellowness) differences were observed between treatments ($p<0.001$). CON presented the lower value and MAJ the highest one, probably associated with the color of coating and essential oil (yellow color). These results were similar to the results found by Abdel-Aziz and Morsy (2015) who, when testing marjoram essential oils on bovine hamburgers, obtained higher b * values for formulations containing marjoram essential oil.

The display period reduced b* values in hamburgers (Table 1). Interaction between treatments and storage was also observed for parameters b*, as shown in Fig. 2.

3.4. Antioxidant activity

The results (Table 1) show that the samples containing cinnamon essential oil, had higher antioxidant activity ($p < 0.01$) than others samples. The great radical scavenging activity of CIN may be associated with the cinnamaldehyde present in cinnamon, a compound known for its high antioxidant activity (Biondo et al., 2017; Dudonné, Vitrac, Coutière, Woillez, & Mérillon, 2009). No interaction between treatments and storage time was observed for the DPPH and ABTS ($p>0.05$) and the antioxidant activity decreased during display time ($p<0.001$)

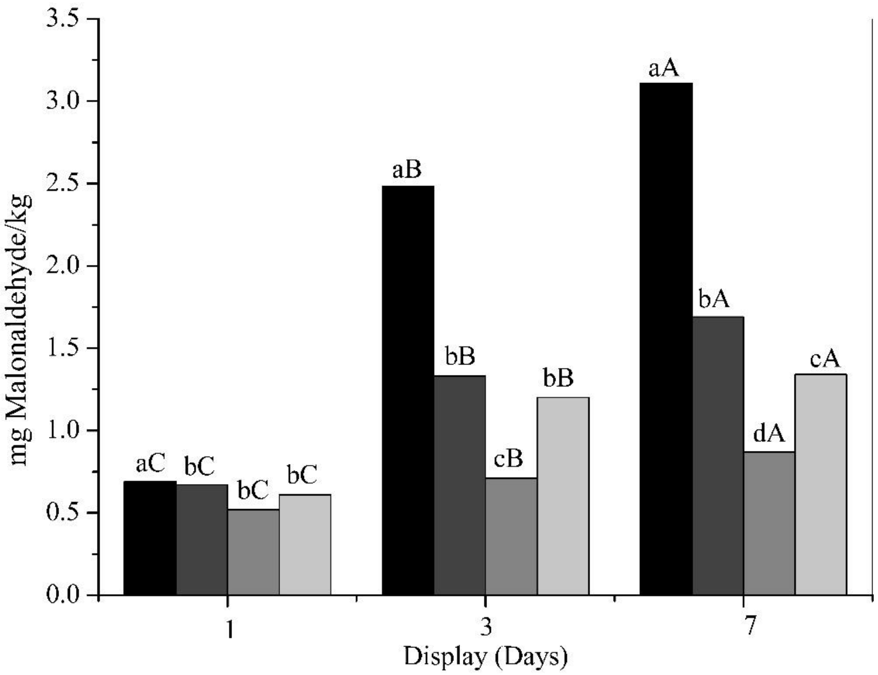
Studies have shown that natural antioxidants used in processed meat showed an antioxidant activity during display (Mir, Masoodi, & Raja, 2017). Khare, Abraham, Rao, and Babu (2016) used an edible coating composed of carrageenan, cinnamon essential oil, and citric acid, and they verified an improvement in the shelf life of chicken under refrigeration due to the antioxidant added. Thus, natural antioxidants have potential to be used in meat industry since they are rich in active molecules and may reduce lipid and protein oxidation during storage (Kumar, Yadav, Ahmad, & Narsaiah, 2015; Zhang, Wu, & Guo, 2016).

3.5. Lipid Oxidation

The inclusion of essential oil in the coating and the display time significantly affected lipid oxidation values (Table 1, Figure 2). TBARS values increased significantly ($P < 0.001$) with display period, and CON showed the highest value. The coating with essential oil decreased oxidation related to CON and ECO, and CIN was the most effective, probably associated to the higher antioxidant activity of cinnamon (Table 1). The phenolic content of essential oils and other active ingredients that act as antioxidants, inhibit the oxidation of oxidizable molecules such as lipids and proteins in meat co-products (Jiang & Xiong, 2016).

An interaction between the effects (treatments and storage time) was also observed to TBARs, as shown in Fig. 2. At the first day, the treatments with coating presented lower values of malonaldehyde than CON ($p<0.05$). At the third and seventh day, the values were lower with coating ($P < 0.05$), highlighting the CIN, which presented the lowest value ($P < 0.05$).

Figure 2. Interaction between treatments and display time on lipid oxidation (TBARS) of Wagyu hamburger. (CON – hamburger without edible coating; ECO – hamburger with edible coating; CIN – hamburger with edible coating containing 0.1% of cinnamon essential oil; MAJ – hamburger with edible coating containing 0.1% of marjoram essential oil).



Source: Authors.

3.6. Scanning Electron Microscopy

ross-sectional micrographs of the hamburger with and without edible coatings are illustrated in Figure 3. Analyzing the microstructure is clear that the coatings covered the hamburgers by filling the pores of the meat surface, and then forming a protective layer. It was observed that hamburgers with coatings presented a compact, homogeneous and smooth surface, confirming the good dispersion of the coating. Similar characteristics have been observed in previous essays on edible coating with essential oils (Battisti et al., 2017; Vital et al., 2016). The homogeneous distribution of the coating is a great indicator of its chemical and structural integrity since these are directly related to improvements in the mechanical properties (Castaño et al., 2017).

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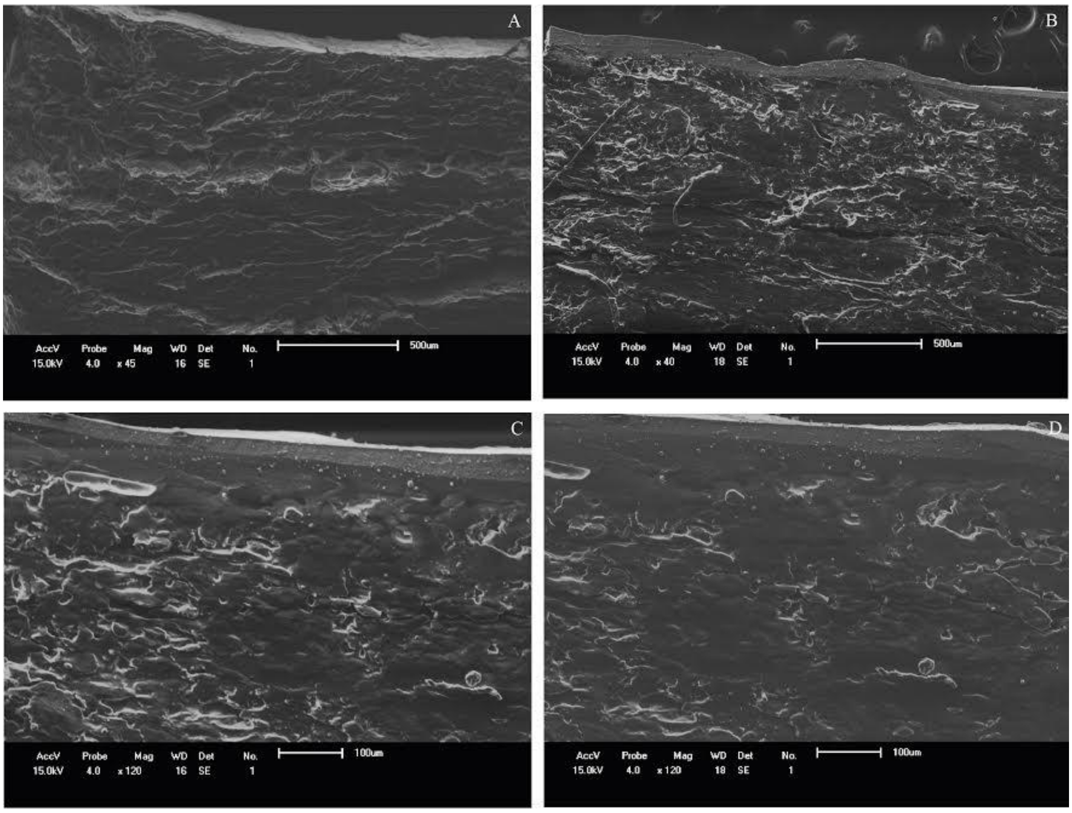
Figure 3. (A) CON – hamburger without edible coating; (B) ECO – hamburger with edible coating; (C) CIN – hamburger with edible coating containing cinnamon essential oil; (D) MAJ - hamburger with edible coating containing marjoram essential oil.

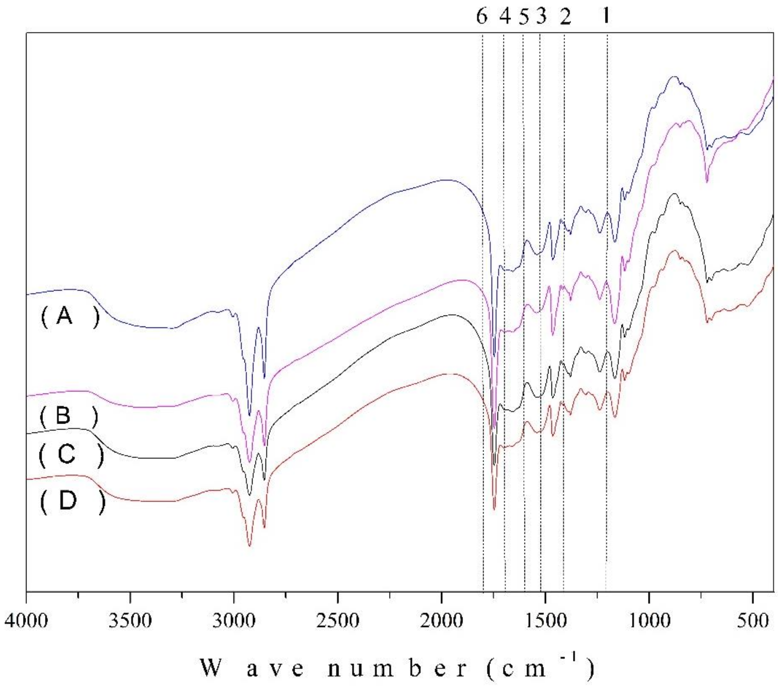


Source: authors.

3.7. FTIR

Figure 4 shows FTIR spectra of cooked hamburgers. Infrared spectrophotometry was used to observe the effect of the coatings on the hamburger after cooking it. The meat structure did not suffer any type of alteration after cooking, because there was no a new peak. Spectra of the samples with and without coating showed no differences in the range 1200-1400 cm^{-1} (1,2) and 1550-1700 cm^{-1} (3,4) attributed to aromatic vibrations and the aldehyde group of the cinnamaldehyde which is the main component of the cinnamon essential oil. In the range of 1600 and 1800 cm^{-1} (5,6) the similarity is attributed to the vibration of the compounds and aromatic rings present in the marjoram (Castaño et al., 2017; Salha, Díaz, Labidi, & Abderrabba, 2017). Probably these modifications did not occur due to the low concentration of the alginate and the essential oils present in the coatings. All treatments had similar spectra. This behavior was also observed by Dicastillo, Bustos, Guarda, and Galotto (2016) when studied crosslinked methylcellulose films with myrtle fruit extract and did not find any modifications in the spectra.

Figure 4. FT-IR spectra of the samples (A) CON – hamburger without edible coating; (B) ECO – hamburger with edible coating; (C) OEC – hamburger with edible coating containing cinnamon essential oil; (D) OEM - hamburger with edible coating containing marjoram essential oil in the 4000-500 cm^{-1} region.



Source: Authors.

3.8. Consumer acceptability

The treatments had a significant effect on odor (p<0.035). The hamburger with cinnamon essential oil had the higher notes, while ECO had the lowest. Con and MAJ were not different than the others (Table 2).

Table 2. Consumer acceptability Wagyu hamburger with edible coating containing cinnamon and marjoram essential oil.

	Treatments					
	CON	ECO	CIN	MAJ	SEM	P<value
Odor	6,7^{ab}	6,37b	6,89^{a}	6,85^{ab}	0,050	0,035
Flavor	6,69	6,36	6,71	6,65	0,090	0,299
Tenderness	6,94	6,80	7,02	7,14	0,077	0,191
Overall acceptability	6,72	6,33	6,73	6,67	0,088	0,195

Means of treatments with different small letters in the same line are significantly different (p < 0.05). [1]CON – hamburger without edible coating; [2]ECO – hamburger with edible coating; [3]CIN – hamburger with edible coating containing 0.1% of cinnamon essential oil; [4]MAJ – hamburger with edible coating containing 0.1% of marjoram essential oil. [5]SEM: Standard error of means *Based on a 9-point scale (1: dislike extremely; 9: like extremely). Source: authors.

These results show that the addition of cinnamon or marjoram essential oils on the hamburger did not alter its tenderness, flavor and overall acceptability, and in some cases (odor) could improve the acceptability of this attribute. Thus, the addition of essential oil besides improving the quality of the hamburger, may also improves its sensorial acceptance. Among the limitations for this type of study is the use of wagyu meat which still has a high cost, however the processing of different cuts, which were less consumed, can give a better destination in addition to adding value to the product.

4. Final Considerations

The addition of essential oils in the edible coatings did not influenced the pH and cooking loss of hamburger. Reduced the water loss and the shear force of the hamburger, in addition to confer antioxidant activity to the product and reduce the lipid oxidation. In general, the hamburger with cinnamon essential oil presented the better results, as in sensory analysis. Thus, the use of coating with essential oil maintained/improved the quality and of hamburgers during their display, showing its possibility use meat products.

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