

Effect of packaging and storage conditions on some quality traits of bovine meat

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Abstract

Packaging is considered one of the most interesting technological aspects of food production and is a constantly evolving subject in food production. The type of packaging is important for the quality and safety of the product and for the visual appearance of the product to be immediately evaluated by consumers. The purpose of this study was to investigate the effect of four different types of modified atmosphere packaging (ATM) and vacuum packaging (VP) currently used by a company in central Italy, on the main qualitative characteristics of beef. For these two traditional and two new solutions with reduced environmental impact and compostable were evaluated. For each type of packaging, two different products were analyzed: steaks and hamburgers. The samples, immediately after production, were transported to the laboratory in refrigerated containers. Several parameters (color, pH, water holding capacity, drip loss, and microbiological characteristics) were evaluated at time 0 and after 7 (T7), 14 (T14) and 21 days (T21)

of storage in the dark and at refrigeration temperature ($+4^{\circ}\text{C} \pm 2^{\circ}\text{C}$). The results showed that the two types of packaging have very similar effects on the water-retaining capacity of the steaks. More noticeable differences were recorded by the colorimetric analysis: for both steaks and hamburgers, the products packaged in the traditional packaging appeared brighter and redder than those packaged in the new alternatives. The microbiological analysis of the steaks showed higher values in the “new” packaging. The formation of abundant ropy slime was observed in one of the samples in the “new” modified atmosphere package at T21. The results of this study showed that the technological characteristics (in particular, the color) and the microbiological characteristics of the steaks and hamburgers were better in “old” packaging, with a better appearance and a longer shelf life. The results obtained show how the research for eco-sustainable products for packaging must be addressed, taking into account the effect of the materials on the qualitative and hygienic-sanitary characteristics of the meat.

Introduction

Meat is a dynamic system with a limited shelf life, mainly due to the high amount of water (about 75%) (Listrat *et al.*, 2016) and the nutritional and sensory properties can change during storage due to microbial activity, physical or chemical changes (Bao, Puolanne, & Erbjerg, 2016). The packaging of such a perishable food is, therefore, not easy. Extending shelf life and increasing meat safety are two important aspects for consumers and for producers (Horbańczuk & Wierzbicka, 2017). Packaging in food production is considered one of the most interesting technological aspects and a constantly evolving theme (Cenci-Goga *et al.*, 2020). Packaging is a coordinated system that prepares products for transport, distribution, storage, marketing, and consumption and performs several functions (Colavita, 2012; Robertson, 2012). The first is containment at any stage of the production, storage, and transport cycle. Packaging also has a second function, that of a barrier against secondary contamination of meat, although the inhibition of the growth of the initial microbiota and contaminant microorganisms cannot rely on packaging alone. In fact, to reduce meat spoilage, the packaging must be associated with other treatments to limit the growth of microorganisms, according to the so-called “hurdles technological” strategy (Leistner, 2000). The third function, of no less importance nowadays, is promotion: in fact, packaging has an effect

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on the technological characteristics of the product, such as color, so much so that it is also defined as a “silent seller” (Piergiovanni & Limbo, 2010). Two of the most used types of packaging for meat are modified atmosphere and vacuum packaging. Modified Atmosphere Packaging (MAP) consists of a technique for reducing the oxygen concentration in the package and involves replacing the air with a gas or gas mixture. Oxygen, nitrogen, and carbon dioxide are used as a mixture in different combinations and proportions depending on the product, the microbiological flora to be inhibited, and the color stability requirements. This method ensures a prolonged shelf-life and a better appearance of the product compared with aerobic packaging (Cenci-Goga *et al.*, 2020; J. Łopacka, Półtorak, & Wierzbicka, 2017). Vacuum packaging (VP); however, is a preservation method that consists of the elimination of most of the air. The main advantages of this technique are an increase in the shelf life of

the product, protection of the food from external dangers, and better handling (Jeremiah, 2001). Although different packaging alternatives are proposed, the common purpose is to ensure high standards, while maintaining the required characteristics for as long as possible. The goal is no longer just to preserve the products, protect them and allow them to not deteriorate in a short time, but also to differentiate the products themselves in a market where competition is high, in addition to responding to the needs of increasingly demanding customers. Another important aspect to consider is the evaluation of the environmental impact of the packaging and its environmental footprint. Packaging in general, and especially plastics, has for recent years seen increasing public awareness of the related environmental challenges, specifically related to littering and marine debris (Lindh, Williams, Olsson, & Wikström, 2016; Svanes *et al.*, 2010). In this perspective, the search for more ecological alternatives to plastic materials is an important challenge for the meat industry. The purpose of this study was to investigate the effect on the main qualitative characteristics of beef of two different types of modified atmosphere (MAP) and vacuum packaging (VP) currently used by a company in central Italy, and two new compostable solutions with reduced environmental impact.

Materials and methods

Experimental design

In this study, two types of products manufactured by a meat processing company located in central Italy were examined: steaks and hamburgers. All samples were produced on the same day from the same animal (in this case, a two-year-old male Chianina breed born, raised and slaughtered in Italy). The animal was slaughtered in a local abattoir according to standard routines, with particular attention paid to minimizing stress factors that can negatively influence the quality of the meat (Iulietto *et al.*, 2018; Poeta *et al.*, 2013). Two types of packaging were evaluated: modified atmosphere package and vacuum package. For each type of packaging, two different types of materials were studied, defined as “old” (the one already used by the company, from now on indicated with the number 1) and “new” (a new proposal, from now on indicated with the number 2). The modified atmosphere packaging currently in use (MAP1) consists of a tray of extruded polystyrene foam, laminated with a multilayer gas barrier film for packaging in a protective atmosphere, while

the “new” one (MAP2) consists of a recycled polyethylene terephthalate mono packaging tray. In both MAPs, the same gas composition was used (60% O₂, 30% CO₂, and 10% N₂). The vacuum packaging currently in use (VP1) consists of a double thermoforming laminate, while the new proposal (VP2) is made up of recyclable paper. At each analysis time, eight samples were analyzed: 1) MAP1 steaks, 2) MAP2 steaks, 3) MAP1 hamburger, 4) MAP2 hamburger, 5) VP1 steaks, 6) VP2 steaks, and 7) VP1 skin, 8) VP2 skin. The samples were stored at a refrigeration temperature (4°C ± 2°C) and in the dark. Analyses were performed weekly four times (T0, T7, T14, and T21). To determine the effect of the different types of packaging, the following parameters were evaluated at each analysis time: microbiological characteristics, pH, color, water holding capacity (WHC), and drip loss (DL). The experimental design is represented in Figure 1.

Microbiological analysis

For each sample, 10 g of meat was homogenized in a sterile bag containing 90 mL of peptone water (PW, Oxoid, Basingstoke, Hampshire, UK) using a stomacher. Decimal dilutions were prepared in sterile tubes containing 9 mL of Maximum

Recovery Diluent (MRD, Oxoid). The dilutions were inoculated in triplicate on different culture media using the spread plate technique. Briefly, 0,1 mL of the sample is placed using a sterile pipette in the center of the Petri dish containing the culture medium and is then evenly distributed over the surface of the culture medium using a sterile plastic L-shaped spatula. Total mesophilic aerobic flora was determined on Plate Count Agar (PCA, Oxoid) at 30°C for 72 h; *Lactococcus* spp. on M17 agar (Oxoid) at 37°C for 48 h; *Lactobacillus* spp. on Man, Rogosa and Sharpe Agar (MRS, Oxoid) pH 5.5, at 30°C for 72 h in anaerobic conditions generated using an anaerobic kit (Oxoid); enterococci on enterococcus agar (ENT, Oxoid), at 37°C for 48 h; *Staphylococcus* spp. on Baird Parker agar (BP, Oxoid) containing egg yolk and tellurite (Oxoid) at 37 °C for 48 h; *Enterobacteriaceae* on violet red bile glucose agar (VRBG, Oxoid) at 37°C for 24 h; total coliforms on violet red bile lactose agar (VRBL, Oxoid) at 37°C for 24 h. The colonies were then counted on all plates, using a special viewer and a colony counting pen (Colony Count, PBI, Milan). The number of colonies was converted to the log of colony-forming units per gram (CFU g⁻¹) and the mean was calculated for each sample.

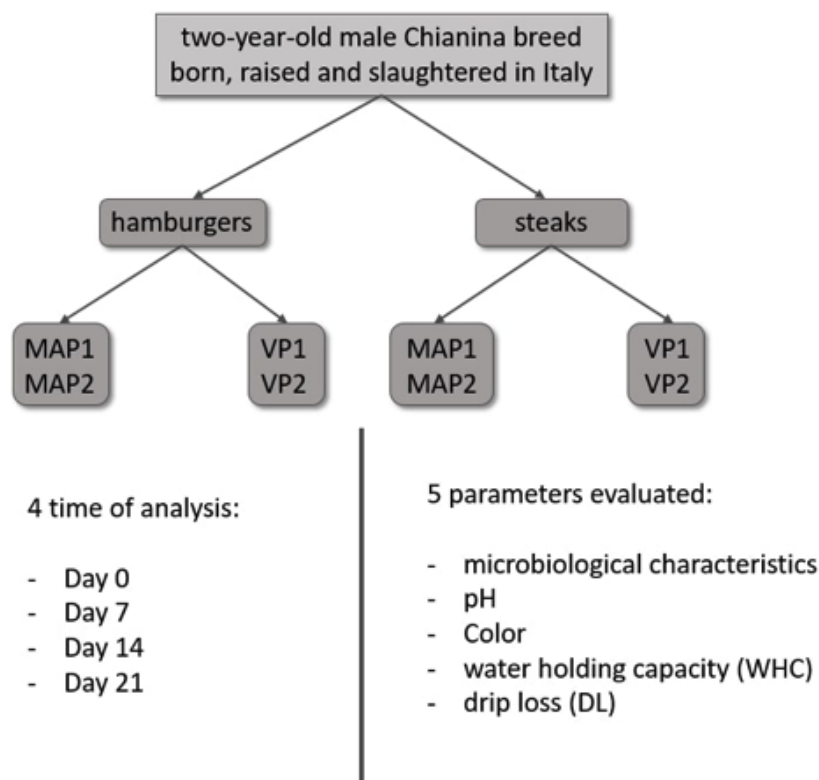


Figure 1. Schematic representation of the experimental design.

pH

To measure the pH, a Double Pore F electrode (Hamilton Company, Reno, NV, USA) hooked up to an Eutech pH 2700 (Eutech Instrument Europe B.V., Landsmeer, Netherlands) was used after mixing 10 g of meat with 90 mL of distilled water. The pH was assessed in each type of product at each sampling time. Each measurement was made in triplicate, and the average was calculated for each sample.

Color

The “ColorMeter RGB Colorimeter” app (White Marten GmbH, Stuttgart, Germany) was used to measure the color of the samples using an iPhone XS with iOS 13.7. The color measurement of each sample was carried out in triplicate before opening the package and ten minutes after opening the package itself. The average was calculated for each measurement. Conventional colorimeters (such as the one described below) are designed to determine the color of a single point in a uniform area. In this case, we chose to measure the average color of the entire product in order to replicate how the consumer perceives his portion of meat. The color measurement of the “ColorMeter RGB Colorimeter” app was calibrated against a reference colorimeter, a Chroma Meter Minolta CR 200 (Konica Minolta Inc. Tokyo, Japan), in order to measure color using the CIELAB scale. Briefly, the Minolta CR 200 Chroma Meter was used to measure a series of red/reddish calibration plates (specifically, CR-A47 DP, CR-A47 R and CR-A47 B) along with a standard white plate to determine the corresponding coordinates in the CIELAB color scale and the results were used to calibrate the reading of the «ColorMeter RGB Colorimeter». The Minolta CR 200 Chroma Meter was set up to measure under CIE D65 standard lighting conditions. D65 is roughly equivalent to the average midday light in Western/Northern Europe, which includes both direct sunlight and diffuse light from a clear sky. This standard has a light color temperature of about 6500 K and is precisely defined as “day-light.” The light used to illuminate the calibration plates for the “ColorMeter RGB Colorimeter” app was therefore a 6500 K light source (Godox Led 64, Godox, Shenzhen, China) under controlled conditions in a photo box. The CIELAB system describes the colors visible to the human eye based on their hue and chroma (position on the a^* and b^* axes) and their brightness, L^* , which corresponds to a position on a black to white scale. The a^* axis is relative to the green-red colors, with negative values indicating a color shifted more towards green and positive values towards red. The

b^* axis represents the blue-yellow colors, with negative numbers towards blue and positive towards yellow.

Water holding capacity

Water holding capacity (WHC) is an attribute of meat of great importance because it affects the appearance of raw meat, its behavior during cooking and its juiciness when chewed. It is defined as the ability of meat not to lose water when external pressure is applied (Hughes, Oiseth, Purslow, & Warner, 2014; Pearce, Rosenvold, Andersen, & Hopkins, 2011). In our study, WHC was measured using the filter paper pressure method (Gebrehiwot, Balcha, Hagos, & W/inkelul, 2018). A fixed amount of sample (1 g) was finely chopped and placed on a filter paper sheet. The samples thus prepared were then placed between two Plexiglas plates. A 5 kg weight was placed on top of the Plexiglas plate for a standard time of 5 minutes. In this way, the water lost by the meat during the “squeezing” is absorbed by the filter paper. This test was repeated in triplicate. All the tests were photographed, and the images thus obtained were used to measure the area occupied by the meat (A_{meat}) and the total area occupied by the meat and the halo of water absorbed (A_{total}). The WHC was calculated using the following formula: $A_{\text{meat}}/A_{\text{total}} * 100$. Higher values of this ratio indicate a greater capacity to retain water.

Drip loss

The drip loss (DL) allows us to determine the quantity of water lost by the meat due to dripping. There are several methods for measuring this parameter. In our study, we used a method called EZ-DripLoss (Torres Filho, Cazedey, Fontes, Ramos, & Ramos, 2017). At each analysis time, plastic boxes containing a perforated pedestal were weighed. A standard-sized fragment (approximately 10 g) of each sample was placed on the pedestal and the box was reweighed. Boxes were then placed at a refrigeration temperature (4°C) for 24 h. The following day, meat samples were removed from the boxes, which were reweighed to determine the amount of water lost by dripping from the meat. The DL value was expressed as a percentage of the starting weight of the meat. Each test was performed in triplicate, and the mean was calculated for each sample.

Statistical analysis

Statistical analysis was performed with GraphPad Prism 6 for Windows (GraphPad Software, San Diego, California). A two-way ANOVA comparison was performed to determine if the likelihood of observed differences between the different types of

packaging was random. The differences were considered significant with a P value <0.05 .

Results and discussion

The results of the qualitative analysis for the samples in MAP are reported in Tables 1-4: Tables 1 (steaks) and 3 (hamburgers) and for samples in VP are reported in Tables 2 (steaks) and 4 (hamburgers). The statistical analysis of the results showed that the two types of packaging have very similar effects on the water-retaining capacity of the steaks. In fact, MAP2 showed better WHC values at T21 and no statistically significant differences were observed in VP samples. Mean values for DL showed no statistically significant differences in both MAP and VP samples. A similar behavior was observed for the pH of the steaks, where statistically significant differences were observed only for VP at T0 (lower pH in VP2). No significant differences were observed at the other times of analysis. Other studies tackled the effect of MAP and VP on the quality of beef meat. A negative effect on the tenderness and juiciness of beef steaks in MAP with high oxygen if compared to VP was observed by Lagerstedt, Lundström, and Lindahl (2011). However, worse quality characteristics for VP compared to MAP were reported by other authors (Moczowska, Póltorak, Montowska, Pospiech, & Wierzbicka, 2017; Zakrys-Waliwander, O’Sullivan, O’Neill, & Kerry, 2012).

More marked differences are highlighted by the colorimetric analyses carried out both on the steaks and on the hamburgers, before and after the opening of the packages. For the steaks, the L^* coordinate values were significantly higher in MAP1 at all analysis times before opening and at T0, T14, and T21 after opening. Similarly, they were significantly higher for VP1 at T14 before opening and at all analysis times after opening. The a^* coordinate values were significantly higher in MAP1 at T7 and T21 before opening and at all analysis times after opening. The same parameter showed significantly higher values at T0, T7 and T14 after opening. The b^* coordinate values were significantly higher in MAP1 at T7 and T14 before opening. The values were significantly higher also for VP1 at T0 before opening and at T0 and T7 after opening. No significant differences were observed at the other times of analysis.

For hamburgers, the L^* coordinate values were significantly higher in MAP1 at T14 and T21 before opening and at all analysis times after opening. Similarly, they

were significantly higher for VP1 at all analysis times both before and after opening. The a* coordinate values were significantly higher in MAP1 at all analysis times after opening. The same parameter showed significantly higher values for VP1 at all analysis times after opening. The b* coordinate values were significantly higher in MAP1 at all analysis times after opening. The same values were significantly higher for VP1 at T0 before opening and at all

analysis times after opening. No significant differences were observed at the other times of analysis.

The data related to the L* and a* coordinates are particularly interesting: these two coordinates respectively indicate the “brightness” of the color and its position on the green-red axis (higher values indicate colors closer to red). These are two characteristics that are of considerable importance in the perception of the consumer who

prefers “brighter” and red products, influencing their choice at the time of purchase (Cenci-Goga *et al.*, 2014). Similar behavior for the color coordinates of beef meat (Joanna Łopacka, Półtorak, & Wierzbicka, 2016) and other types of meat (Horbańczuk, Józwiak, Wyrwicz, Marchewka, & Wierzbicka, 2021) in MAP are reported in literature.

The results obtained during the microbiological analysis of the steaks are reported

Table 1. Mean values of the parameters analyzed for steaks in MAP.

	T0		T7		T14		T21	
	MAP1	MAP2	MAP1	MAP2	MAP1	MAP2	MAP1	MAP2
WHC	19,70	19,49	19,08	22,88	24,44	24,21	19,66*	32,27*
DL	0,76	0,97	3,13	2,65	3,70	4,44	1,83	1,83
pH	5,89	5,51	5,64	5,44	5,56	5,52	5,9	6,04
L (bo)	50,33*	40,33*	51,67*	38*	55,67*	39*	53,33*	37,33*
a (bo)	28,33	25,67	23*	17,33*	17,33	14	22,67*	13,33*
b (bo)	26	25	28*	21*	30,33*	22,67*	23	20,33
L (ao)	54,67*	39*	50,33	52,67	57,67*	45,33*	56*	39,67*
a (ao)	40*	31*	41,33*	20,67*	30,67*	21*	27*	19,67*
b (ao)	36,67	30,33	28,33	26	33,67	30,67	29,67	27,67
PCA	3	3,3	2,95	4,05	3,08	4,48	3,2	4,7
MRS	-	-	2,7	4,26	3,63	4,7	2,48	3,7
M17	-	3	-	4,04	3,62	4,58	4,34	4,55
BP	3	-	-	2,78	2	-	2,7	2
ENT	-	-	-	-	-	-	-	-
VRBG	-	-	-	3,9	-	4,48	-	-
VRBL	-	-	-	-	-	-	-	-

bo, before opening; ao, after opening; *mean values for the same parameter at each time of analysis that differ significantly between the two types of packaging at P<0.05.

Table 2. Mean values of the parameters analyzed for steaks in VP.

	T0		T7		T14		T21	
	VP1	VP2	VP1	VP2	VP1	VP2	VP1	VP2
WHC	24,17	24,17	18,98	24,88	23,27	22,63	33,37	26,29
DL	0,87	0,51	2,31	3,84	4,90	3,22	1,26	1,29
pH	5,63*	5,5*	5,7	5,73	5,73	5,67	5,69	5,73
L (bo)	47	31	51	46,33	48,33*	31,33*	46	34
a (bo)	15	13	18,67	23,33	20	18	24,67	18,33
b (bo)	30*	14,67*	21,33	22	16,67	16,67	19,33	18
L (ao)	56,67*	32*	51,33*	37,33*	50*	29,33*	46,33*	35,67*
a (ao)	14,33*	20,33*	34*	24,33*	32,67*	25,33*	30,67	27,33
b (ao)	26,67*	14,67*	28*	20,67*	24	20,33	22	23,67
PCA	-	4,54	3	3,88	2,3	3,28	2,6	2,3
MRS	3,7	4,35	-	-	2,3	2,6	2,48	2,3
M17	-	3,5	2	-	2	2,85	3,26	2,6
BP	3	3,48	2,7	2,9	2,6	2,6	2	2
ENT	-	-	-	-	-	-	-	-
VRBG	-	-	-	-	-	-	-	-
VRBL	-	-	-	-	-	-	-	-

bo, before opening; ao, after opening; *mean values for the same parameter at each time of analysis that differ significantly between the two types of packaging at P < 0,05.

in tables 1 (MAP) and 2 (VP). Microbiological analysis of the steaks showed on average higher results for MAP2 and VP2. This pattern was observed in MAP2 for total mesophilic aerobic flora at all test times, for lactobacilli at T7, T14 and T21 and for lactococci at all test times. Similarly, for VP2, the values were higher for total mesophilic aerobic flora at T0, T7 and T14, for lactobacilli at T0 and T14, for lactococci at T0, T14 and T21 and for

staphylococci at T0 and T7. The formation of abundant ropy slime was observed in one of the samples in one of the MAP2 packages at T21. "Ropy slime" is a typical alteration of the surface of vacuum packed or modified atmosphere meats, both cooked and raw. It is linked to the formation of a biofilm by particular bacterial species (*Lactobacillus* spp. and *Leuconostoc* spp. among the most common) (Cenci-Goga, Sechi, et al., 2020).

The results obtained during the microbiological analysis of the hamburgers are reported in tables 3 (MAP) and 4 (VP). The microbiological analyses carried out on the hamburgers showed initial bacterial populations more abundant than the steaks, as can be expected considering that the meat that constitutes them has already undergone a transformation process and that other ingredients are added. Higher values for MAP2 if compared to MAP1 were observed in the

Table 3. Mean values of the parameters analyzed for hamburgers in MAP.

	T0		T7		T14		T21	
	MAP1	MAP2	MAP1	MAP2	MAP1	MAP2	MAP1	MAP2
DL	0,79	0,37	1,18	1,03	2,57	1,71	0,63	0,39
pH	5,76	5,75	5,76	5,81	5,76*	5,84*	5,8	5,75
L (bo)	49,67	43,33	50,33	50	54*	28,67*	54*	35,67*
a (bo)	31	22,67	32	23	24,67	21,67	20,67	9,67
b (bo)	31,67	22,67	26	21,67	29	22	22,33	15,67
L (ao)	56,67*	42*	54*	38,33*	57,33*	40*	59*	38,33*
a (ao)	41,33*	27,67*	39*	30*	38,33*	24,33*	35*	12*
b (ao)	37,33*	28*	36,33*	29*	32,67*	27*	39,33*	23,33*
PCA	4,1	3,98	3,99	4,48	4,38	4,6	4,43	4,42
MRS	3,78	3,6	4,2	4,3	4,48	4,6	4,6	4,64
M17	3,48	4,15	3,94	4,44	4,42	4,66	4,59	4,6
BP	3,89	4	3,51	3,54	3,72	3,56	3,54	3,04
ENT	-	-	2	-	-	-	-	-
VRBG	3,48	3,78	3,53	4,17	3	4,48	3	4,48
VRBL	-	-	-	2,3	2,6	2	2,7	2

bo, before opening; ao, after opening; *mean values for the same parameter at each time of analysis that differ significantly between the two types of packaging at P <0,05.

Table 4. Mean values of the parameters analyzed for hamburgers in VP.

	T0		T7		T14		T21	
	VP1	VP2	VP1	VP2	VP1	VP2	VP1	VP2
DL	0,22	0,46	0,38	0,43	0,58	1,1	0,49	0,99
pH	4,59*	4,92*	5,77	5,81	5,74	5,76	5,77	5,8
L (bo)	57,33*	32*	51*	39,33*	56*	31,67*	59*	35,33*
a (bo)	16	14,67	23,33	16,67	24,67	19,67	24	18,33
b (bo)	32,33*	19,67*	24,67	14,67	25,33	22,33	27	18,67
L (ao)	59*	32,33*	58,67*	36,33*	57,33*	32,67*	58,33*	34,67*
a (ao)	25,33*	19,67*	34,67*	24,67*	27,67*	23*	33*	26*
b (ao)	30*	17,33*	31,67*	19,67*	29,33*	22*	29*	21,33*
PCA	4,23	4,33	3,97	3,92	4,52	4,45	4,04	3,98
MRS	4,04	3,95	4,19	3,95	4,6	4,53	4,59	4,56
M17	3,65	4,15	4,08	3,91	4,55	4,46	4,44	4,45
BP	3,7	3,9	3,38	3,77	3,86	3,36	3,6	3,89
ENT	-	-	-	2,3	-	-	-	-
VRBG	-	3,48	3,3	3,15	3,57	2,85	2,78	3,26
VRBL	-	-	2,3	-	2,3	2	2,3	2

bo, before opening; ao, after opening; *mean values for the same parameter at each time of analysis that differ significantly between the two types of packaging at P <0,05.

total mesophilic aerobic flora at T7 and T14, in the lactococci population at T0, T7, and T14 and in the lactobacilli population at T7 and T14. *Staphylococcus* spp. count was higher in MAP2 at T0, while it was higher in MAP1 at T14 and T21. Populations of *Enterobacteriaceae* were also observed in hamburgers stored in both MAP and VP, which were absent in the steaks. Enterococci were detected only at T7 in MAP1 and VP2.

Most of the packaging materials currently in use for foods are made from plastic and approximately 95% of them are not recycled and go to landfills after a short single-use, causing extensive environmental damage and an estimated loss to the global economy of \$80–120 billion every year (Wu, Misra, & Mohanty, 2021). In this scenario, there is a growing scientific and industrial interest in the development of recyclable and biodegradable alternatives. Despite the undeniable advantages provided by these materials, various challenges remain for practical packaging applications. First of all, there are few biodegradable polymers available on the market that can satisfy the high demand for food packaging in our society. Secondly, it's hard to obtain performance comparable to traditional petroleum-based plastics, in particular as regards the function of the oxygen/water vapor barrier, which is essential for the correct storage of foods (Mohanty, Vivekanandhan, Pin, & Misra, 2018). The results obtained in this study seem to confirm this difficulty. In fact, the two new compostable solutions with reduced environmental impact (MAP2 and VP2) showed worst effect, mainly on the color of the meat. This is probably related to a worst capacity to maintain the correct oxygen concentration inside the packaging, which is essential to keep the desired color of the meat (Bao *et al.*, 2016).

Conclusions

The term “packaging” refers to technological intervention aimed at the protection of foods from a variety of factors that could cause product spoilage. Packaging is regarded as one of the most interesting technological aspects and a matter of continuous evolution in food production. The purpose of this work was to evaluate the effect of two types of modified atmosphere packaging and skin on hamburgers and steaks produced by a company in central Italy. The results obtained in this study showed that the technological characteristics (in particular the color) and the microbiological characteristics of the steaks and hamburgers

were better in packaging in ATM1 and SKIN1 than in the new types of packaging (ATM2 and SKIN2). The two new compostable solutions with reduced environmental impact (MAP2 and VP2) showed worst effect mainly on the color of the meat. This is probably related to the poor capacity to maintain the correct oxygen concentration inside the packaging, which is essential to keep the desired color of the meat.

The type of packaging today is very important, in particular, for the visual appearance of the product, which immediately assesses the consumer. However, we must not forget that the quality and safety of the product inside the packaging are always the main feature to be taken into consideration. The new type of packaging used does not seem to satisfy these qualitative requirements, while the two “old” types of packaging seem to guarantee a better appearance and a longer and safer shelf life.

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