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FOOD TECHNOLOGY

Natural extracts marination in chicken breast fillets

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ABSTRACT: *This study evaluated the effects of natural extracts on chicken breast fillet marinades regarding the physicochemical properties, oxidative stability, and the Staphylococcus aureus and Escherichia coli inhibition during 21 days of storage. Chicken breast fillets (Pectoralis major) (128 units) purchased in a local market, were used, allocated in a completely randomized block design, in a 4 x 4 factorial scheme (antioxidant x storage time), totalling 16 treatments with eight replicates. The TBARS and the pH values were not influenced by the analyzed factors. For the color results, the values of L^* and b^* were lower in the marinated chicken breast fillets with basil and BHT, respectively. When assessing the effect of storage time, an increase in oxidation was observed up to 21 days of storage. For pH, a quadratic decrease after storage with an increase in the pH value from the 11th day of storage was observed. In the color results, there was a linear decrease in the L^* value during the storage period and in the value of b^* a quadratic effect was observed with a reduction of this intensity up to 21 days of storage. In relation to the value of a^*, a quadratic effect with an increase in the red intensity from the 7 days of storage was observed. For the counting of the S. aureus, the treatments presented 10^2 CFU/g up to 14 days, except for the basil which exceeded the limit established by the legislation at 14 days.*
Key words: *chicken, lipid oxidation, marinated, natural antioxidants.*

Extratos naturais na marinação de filés de peito de frango

RESUMO: *O objetivo deste estudo foi avaliar os efeitos de extratos naturais em marinados de filés de peito de frango sobre as propriedades físico-químicas, estabilidade oxidativa e inibição Staphylococcus aureus e Escherichia coli durante 21 dias de armazenamento. Foram utilizados 128 filés de peito de frango (Pectoralis major) adquiridos no mercado local, alocados em delineamento de blocos inteiramente casualizados em fatorial 4 x 4 (antioxidante x tempo de armazenamento), totalizando 16 tratamentos com oito repetições. Os valores de TBARS e pH não foram influenciados pelos tratamentos. Para os resultados de cor apenas os valores de L^* e b^* foram influenciados pelos tratamentos, sendo os menores valores encontrados no tratamento com manjericão e BHT, respectivamente. Avaliando o efeito do tempo de armazenamento observou-se aumento da oxidação até 21 dias de estocagem. Para o pH verificou-se diminuição quadrática após a estocagem com aumento no valor do pH a partir do 11º dia de armazenamento. Nos resultados de cor, verificou-se queda linear no valor L^* durante o período de armazenamento e no valor de b^* observou-se efeito quadrático com redução dessa intensidade até 21 dias de estocagem. Em relação ao valor de a^* observou-se efeito quadrático com aumento da intensidade a partir dos sete dias de armazenamento. Para contagem de S. aureus, os tratamentos apresentaram $<10^2$ UFC/g até 14 dias, exceto o manjericão que aos 14 dias excedeu o limite estabelecido pela legislação.*
Palavras-chave: *antioxidantes naturais, carne de frango, marinados, oxidação lipídica.*

INTRODUCTION

Due to the growing demand for fast food and domestic convenience, the production of chicken breast fillets has been diversified. Therefore, chicken breast marinated fillets fulfill the needs of post-processed industries and satisfy consumers' demands for meat, being a semi-prepared product alternative with longer shelf life, thus, increasing consumption options for meat from poultry (RIMINI et al., 2014).

Marinating is a traditional technological process whose penetration or diffusion of brine, commonly prepared with vinegar and spices, promotes improvement in the texture, flavor, and protein functionality (RIMINI et al., 2014; FELLENBERG et al., 2020). In addition, it provides water retention and product yield (ALAHAKOON et al., 2014). Thus, it improves the microbiological quality of the product and increases its shelf life (BALTIĆ et al., 2015; KARAM et al., 2020; OSAILI et al., 2021).

However, contamination of meat by microorganisms, as well as lipid oxidation, are still outstanding issues for the processing industry. As chicken meat has a high content of unsaturated fatty acids in its composition, this food is highly susceptible to lipid oxidation (RIMINI et al., 2014).

Thus, in order to prevent or delay the oxidation of fats, antioxidants are used,

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especially synthetic ones (BASANTA et al., 2018; FELLENBERG et al., 2020). However, its use has been questioned by consumers, due to the toxic effect (BASANTA et al., 2018). Thus, research with plant derivatives, such as extracts and essential oils that have the same function and efficiency as synthetic additives has been increasingly performed.

Spice extracts such as oregano, rosemary, coriander, thyme and basil, among others, may be potential natural antioxidants in meat products (FELLENBERG et al., 2020). In addition, they are inhibitors of food-borne microorganisms due to the presence of phenolic compounds in their composition (BOSKOVIC et al. 2017; STANOJEVIC et al., 2017; BOSKOVIC et al., 2019; KARAM et al., 2020; OSAILI et al., 2021). Furthermore, studies have shown the influence of the use of natural additives on the color (MILANI et al., 2010) and flavor of meat products (BOSKOVIC et al., 2019).

The compounds with the greatest antioxidant potential are carnosic acid and carnosol present in rosemary extract. (MIRA-SÁNCHEZ et al., 2020), thymol and carvacrol present in oregano (GARCÍA et al., 2017; BOSKOVIC et al., 2019) and linalool, thymol and carvacrol present in basil (STANOJEVIC et al., 2017).

Therefore, the addition of spices in chicken meat may contribute to its conservation, as it minimizes oxidative processes and its microbiological action during processing or storage (RIMINI et al., 2014; PATEIRO et al., 2018).

Although, studies have demonstrated the efficiency of the marination process or the use of natural extracts on the antioxidant and antimicrobial activity in meat products, the evaluation of its influence on chicken breast fillets is still scarce. Thus, the present study was carried out to evaluate the effect of oregano, rosemary, and basil extracts added to the marinade on oxidative stability, physicochemical properties and inhibition of *Staphylococcus aureus* and *Escherichia coli* in chicken breast fillets by 21 days of storage.

MATERIALS AND METHODS

The experiment was conducted at the Meat Laboratory of Embrapa Pantanal and 128 chicken breast fillets (*Pectoralis major*) from boneless and skinless, standardized in a weight range between 150 and 200 g, purchased in a local market were used. The fillets were purchased in four periods, in the months of May, June, July and August, and in each period eight chicken breast fillets were used, all from the same batch, for each treatment, totaling 32 steaks per period.

A completely randomized block design, in a 4 x 4 factorial scheme (antioxidant x storage time), totaling 16 treatments with eight replicates was performed. Each collection (period) was considered a block, thus minimizing the effects of the different processing and storage conditions in which the chicken breast fillets were submitted before acquisition.

Brine and marination preparation

The solution for the chicken breast fillets marination was prepared with distilled water, boiled and cooled at 5 °C, 3% of salt (NaCl), 5% of sodium tripolyphosphate ($Na_5P_3O_{10}$) and 1.0% of acetic acid ($C_2H_4O_2$) having been added to it. The antioxidants under test: butyl hydroxy toluene (BHT) (0.01%), oregano (0.2%), rosemary (0.2%) and basil (0.2%) were added to this brine. Dehydrated and packed hermetically spices were purchased in a local market. The marination process was performed by injection and immersion. The brine was injected into the chicken breast fillets, with the aid of a syringe and a needle, in the proportion of approximately 7% of its initial weight, focusing on injecting the solution evenly throughout the meat cuts. Immediately, after the injection, the chicken breast fillets were submerged into the brine in a ratio of 1.5: 1 (v / w), and placed under refrigeration at 5 °C where they remained for six hours. Then, chicken breast fillets were drained for 30 minutes, packed in sterile polyethylene bags, and stored under refrigeration at 5 °C for the thiobarbituric acid reactive substances (TBARS) analysis, color (L^*, a^* and b^*), pH, *Staphylococcus aureus* and *Escherichia coli* one day after the marination and at the intervals of 7, 14 and 21 days of storage.

Lipid oxidation (TBARS)

In order to determine which substances, react to the thiobarbituric acid (TBARS), 50 mL of trichloroacetic acid solution (TCA), composed of 7.5% TCA and 0.1% of propyl gallate was mixed with approximately 10 g of the sample, homogenized for 1 minute and filtered. Test tube with 1 mL of 7.5% TCA solution and 5 mL of 0.02% TBARS solution were added and mixed with 4 mL of the filtrate, modified method (VYNCKE, 1970). These tubes were heated in a water bath for 40 minutes, cooled in water and then, absorbances were read in a spectrophotometer at a wavelength of 538 nm. The results were expressed as mg of malonaldehyde (MDA) per kg of sample.

Measures of pH and instrumental color

In order to determine pH, a portable digital potentiometer (Toledo®), composed of a meat electrode, was inserted directly into the samples. The determinations were performed in triplicate, using three samples with one reading being carried out in each chicken breast fillet.

The instrumental color was determined by a Minolta® colorimeter (model CR-10), at a 90° angle, at room temperature. The color measurements were performed in three chicken breast fillets and two readings were carried out in each chicken breast fillet, totaling six readings for each treatment analyzed. The values of L^*, a^* and b^* were based on the CIELAB system according to HOUBEN (2000). The value of L^* determines the chromium associated with brightness ($L^* = 0$ black, $L^* = 100$ white), a^* the chrome that varies from green (-a) to red (+ a); and b^* which varies from blue (-b) to yellow (+ b).

Microbiological analysis

The microbiological analysis was performed using the Petrifilm® membranes. It Was added 25 g of each sample grounded and 225 ml of 0.1% peptone water and then mixed in a sample homogenizer (Marconi Mark, model MA 440 / CF) for 60 seconds. Then, 9.0 ml of peptone water was placed in sterile stomacher bags and 1 ml of this dilution was seeded in a duplicate in Petrifilm® membranes, specific for counting *Staphylococcus aureus* and *E. coli*. Subsequently, the membranes were incubated and kept in an oven at 35 °C for 24 hours in order to analyze the *S. aureus,* and 48 hours for the *E. coli* following the manufacturer's recommendations.

The colony count of *Staphylococcus aureus* and *E. coli* was performed in the circular growth area, considering the total number of red-violet colonies such as *Staphylococcus aureus* and bluish-red colonies with gas production observed through the development of adjacent blisters to the colony such as *E. coli* (SANTANA & AZEREDO, 2005).

Statistical analysis

The data were statistically analyzed using the RStudio software (R Core Team, 2014). The data were initially submitted to normality analysis by the Shapiro-Wilk test. The data were submitted for analysis of variance and the means were compared by the Tukey test, to evaluate the effects of the treatments and test the factorial, adopting the significance level of 5%.

For the evaluation of color, pH and TBARS data as a function of storage time, a polynomial regression analysis was performed, adopting a significance level of 5%.

RESULTS AND DISCUSSION

There was no interaction between the different antioxidants studied for the values of TBARS, pH and the chicken breast fillet color (Table 1). The TBARS values are used as indicators of the degree of lipid oxidation and are quantified in milligrams of malonaldehyde (MDA). Regarding the lipid oxidation results, no difference ($P > 0.05$) was observed between treatments.

Plants such as rosemary, oregano and basil have antioxidant properties due to their content of bioactive substances, such as phenolic compounds, among others (FELLENBERG et al., 2020).

Phenolic compounds have the ability to eliminate free radicals by donating a hydrogen atom or electron to a free radical and converting them into more stable non-radical products (ZHANG et al., 2016). Therefore, studies with extracts of spices such as oregano, rosemary, and basil proved that these additives have antioxidant effects due to the presence of compounds such as carnosic acid and carnosol in rosemary extract (MIRA-SÁNCHEZ et al., 2020), thymol and carvacrol in oregano (GARCÍA et al., 2017; BOSKOVIC et al., 2019), and linalool, thymol and carvacrol in basil (STANOJEVIC et al., 2017).

Different results of the present study were reported by RACANICCI et al. (2004), in which was compared the antioxidant action of dried rosemary leaves and oregano (both added at 0.10%) in chicken meatballs and reported that the rosemary extract showed superior action to oregano.

The difference between the aforementioned study and the present study may be related to the way in which the meat product was found, because when the meat is minced, the contact surface increases, which may provide better incorporation of additives in use, suggesting that oregano makes it as effective as 0.20% rosemary on minced cuts of meat.

LARA et al. (2011), when evaluating the antioxidant potential of the rosemary extract and the BHT added to pork hamburgers, observed that the natural extract exerted a greater protective effect against lipid oxidation than the one exerted by BHT. Likewise, SÁNCHEZ-ESCALANTE et al. (2003), when evaluating the antioxidant action of ascorbic acid, oregano extract, and lycopene, verified lower TBARS values in crumbed beef treated with oregano.

Despite the differences between the meat models used in the study of the authors mentioned above, the results demonstrated the possibility of replacing synthetic antioxidants such as BHT by natural extracts with antioxidant activity, since synthetic

Table 1 - TBARS (mg of malonaldehyde/Kg sample), pH and color (L *, a * and b *) of chicken fillets marinated with different antioxidants during storage for 21 days at 5 °C.

Parameters	TBARS	pH	Color		
			L^*	a^*	b^*
Treatments	Mean ± SEM	Mean ± SEM	Mean ± SEM	Mean ± SEM	Mean ± SEM
BHT	0.32±0.04	5.79±0.03	58.68±0.47 a	-9.54±0.12	17.83±0.23 b
Oregano	0.32±0.03	5.76±0.04	58.40±0.45 a	-9.90±0.74	18.43±0.16 a
Rosemary	0.35±0.02	5.74±0.04	57.94±0.39 a	-9.71±0.37	18.51±0.19 a
Basil	0.40±0.03	5.77±0.04	56.61±0.53 b	-9.68±0.15	18.48±0.21 a
----------Storage time (days)----------					
1	0.24±0.02	5.84 ±0.03	59.56±0.39	-9.83±0.31	17.85±0.22
7	0.28±0.02	5.69±0.04	58.43±0.37	-11.44±0.31	18.35±0.16
14	0.42±0.03	5.69±0.05	58.10±0.41	-9.79±0.31	18.77±0.19
21	0.43±0.03	5.82±0.04	55.54±0.46	-7.80±0.31	18.28±0.20
----------P value----------					
Antioxidant (A)	0.0589	0.5655	0.0001	0.8960	0.0251
Time (T)	<0.0001	<0.0001	<0.0001	<0.0001	0.0052
A x T	0.3179	0.4454	0.6537	0.9991	0.7435

a-bMeans with the same letter within each column are not significantly different (P > 0.05).
SEM: standard error of mean;
BHT: butyl hydroxy toluene.

antioxidants are increasingly restricted because of the limitations of use by the legislation and by the preference of the consumer for natural additives.

The mean pH values ranged from 5.77 to 5.79 and were not influenced (P < 0.05) by the treatments studied. CARVALHO et al. (2013) reported pH values between 5.46 and 6.10 in chicken breast marinades when garlic, annatto, turmeric, chilli pepper, black pepper, oregano and marjoram were added.

Different results from the present study were found by LYTOU et al. (2017), in which were reported pH results in marinated chicken breasts using pomegranate juice with values from 5.0 to 5.3.

The use of different natural antioxidants influenced some color parameters in the present study. In this regard, the treatment with BHT was significantly different from those with natural additives in the b^* value (P < 0.05). On the other hand, the treatment with basil showed a different L^* luminosity from the other treatments.

Differences between treatments may be expected due to the antioxidant capacity of natural extracts and BHT on the marinated product under the conditions of this research. Different antioxidant capacities may lead to different degrees of lipid oxidation in meat products. The fact that lipid oxidation influences meat color has been previously reported (MOLLER & SKIBSTED, 2006; FAUSTMAN et al., 2010; VIANA et al., 2017; ZHUANG & BOWER, 2016) promoting a discoloration process over time and impacting the luminosity and color pattern of the meat.

MOLLER & SKIBSTED (2006) explain that oxidation influences the state of myoglobin, giving rise to molecular variations that promote discoloration in meat and meat products. This is potentially due to the interaction of secondary products of lipid oxidation with myoglobin, which may accelerate protein oxidation and, consequently, decrease color stability (FAUSTMAN et al., 2010).

Table 1 shows that the basil treatment that showed higher values of oxidation measured by the TBARS method showed a significant difference in the L value, evidencing a lower luminosity in these samples. It is important to note that other factors may influence the color of marinated products, such as pH and the initial color presented by raw breast fillets in natura. Regarding the value of a^*, no difference was observed (P > 0.05) between the treatments.

In chicken breast marinades with the addition of several spices, (garlic, annatto, turmeric, pepper, black pepper, oregano and marjoram), different results were reported by CARVALHO et al. (2013) for L^*, a^* and b^* values of 63.30, 1.58 and

36.07, respectively. Variations in the raw material color and the addition of several condiments not used in this experiment may indicate the differences of luminosity observed between the studies.

When evaluating the effect of storage time, a linear increase in TBARS values (Figure 1) was observed with the advancement of the storage period. This effect may be related to the high content of unsaturated fatty acids in chicken meat, limiting their storage for extended periods. The substrates of the fatty acid reactions are the unsaturated fatty acids; therefore, the degree of unsaturation is what influences the most the oxidation velocity even in frozen meat (RIMINI et al., 2014).

Studies have shown the antioxidant action of natural extracts in meat products and the increase of the TBARS value during storage time, which is in accordance with the results obtained in this experiment. BORBA et al. (2012), when evaluating the addition of 0.15% of rosemary or oregano in fresh sausages made with chicken meat, observed for both treatments an increase in the TBARS values during 9 days of storage under refrigeration at 4 ºC. Similarly, RIMINI et al. (2014), when evaluating the antioxidant action of the thyme and orange essential oils blend (1:1) on the shelf life extension of chicken marinades, verified an increase of oxidation during 12 days of storage.

FELLENBERG et al. (2020) evaluating the addition of 470 mg l^{-1} of oregano and 7.2 ml l^{-1} of rosemary in fish fillet marinades, observed for both treatments an increase in TBARS values during 6 days of storage under refrigeration at 4 ºC.

For pH, a quadratic decrease ($P < 0.05$) was observed after the storage of the marinated steaks with an increase in the pH value from day 11 of storage (Figure 2).

The initial pH reduction is related to the action of the organic acid used in the marination (acetic acid) as observed by ERGEZER & GOKCE (2011). The use of sodium tripolyphosphate in the concentration used in this study did not increase pH by increasing the ionic strength and the interaction with actin and myosin as verified by WYNVEEN et al. (2006), due to the interference of the organic acid with the pH of the system.

Conversely, the increase in the pH value observed from the 11th day of storage may be associated with the exponential increase of bacteria, especially the gram-negative ones that cause proteins and amino acids degradation, resulting in an ammonia formation that increases pH (VERMA & SAHOO, 2000). At 21 days of storage, the samples presented pH elevation, reflecting the state of deterioration that the product presented in the last days of storage.

During the storage period it was possible to observe a linear decrease in the L^* value (Figure 3A). This reduction may be related to the addition of the organic acid in the marination, which favours the

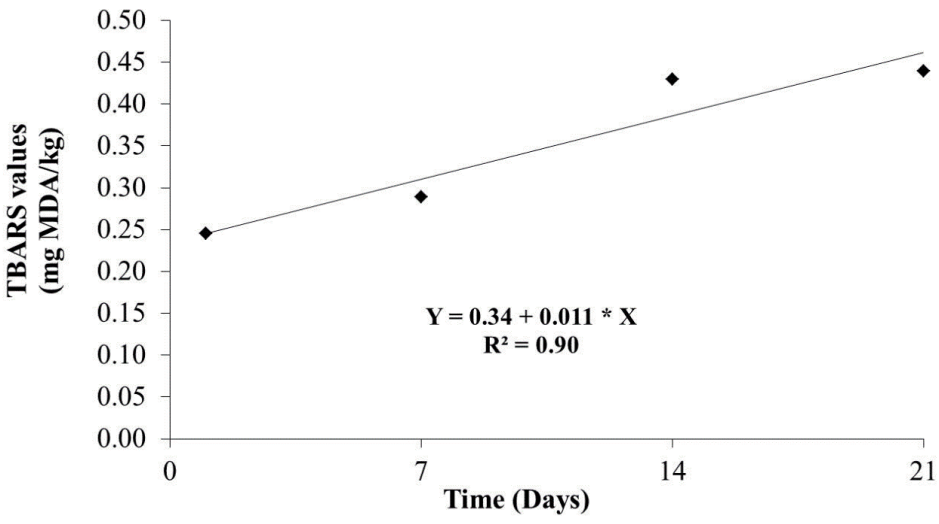

Figure 1 - TBARS (mg of malonaldehyde/Kg sample) of chicken fillets marinated with different antioxidants during storage for 21 days at 5 °C.

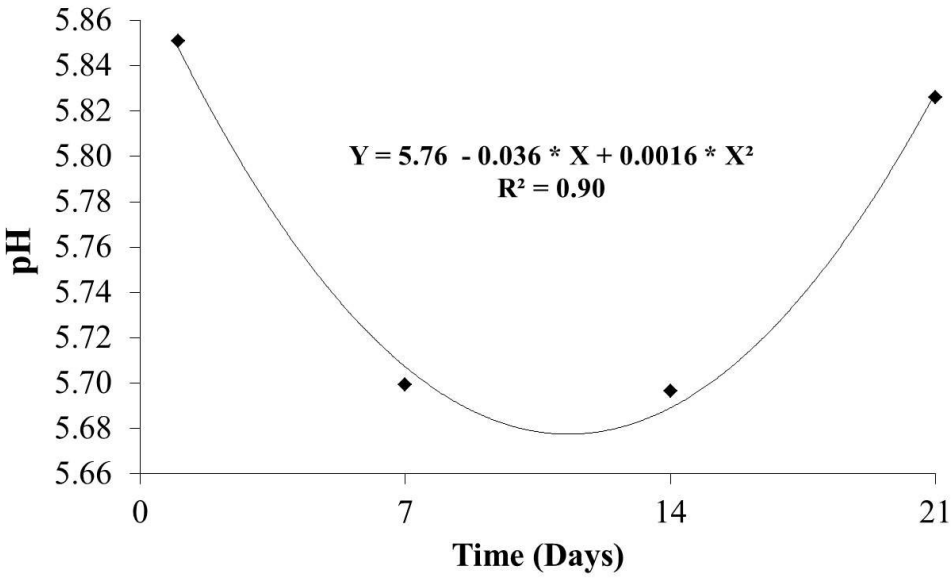

Figure 2 - pH of chicken fillets marinated with different antioxidants during storage for 21 days at 5 °C.

oxidation process of myoglobin to methamoglobin with consequent luminosity loss (AKTAŞ & KAYA, 2001).

The decrease in pH, as observed in this study in the first days of storage, may also cause this variation in the L* value (WHITING & STRANGE, 1990). However, the results showed that the pH decrease was not enough to change the reflectance property of the muscle fibers to the point of increasing the L^* value, thus, prevailing the effect of myoglobin oxidation. The addition of sodium tripolyphosphate, which is known to increase the water retention capacity of the system, may have influenced the result.

For the value of b^* (yellow intensity), there was a quadratic effect as result of the storage time, with a reduction of this intensity up to 21 days of storage (Figure 3C). Similar behaviour was reported by MILANI et al. (2010), when evaluating the addition of two natural extracts, hydroethanolic extract of persimmon cv kyto and hydroethanolic extract of yerba mate in ground and heat-treated chicken. A reduction in the value of L^* and b^* during 14 days of storage was observed.

In relation to the value of a^* (red intensity), a quadratic effect was observed as result of the storage time (Figure 3B), with an increase in the intensity from 7 days of storage. The color change in food occurs due to the myoglobin molecule susceptibility, particularly iron, to suffer state modifications with the chemical changes. Therefore, the generation of red pigments observed throughout the storage time may be explained by the increase of the oxidation forming ferrylmyoglobin (BREWER, 2004).

Different behavior was reported by MILANI et al. (2010), who observed a reduction in the value of a^* in ground beef during 14 days of storage. The results related to the *Staphylococcus aureus* of the marinated chicken breast fillets are shown in table 2. *E. Coli* (CFU/g) was not reported throughout the storage time in any of the treatments, indicating that there was no excessive contamination during the handling and the storage of the chicken breast fillets (data not shown).

Results obtained for *S. aureus* were < 10^2 CFU / g for all treatments up to seven days of storage ($P < 0.05$). At 14 days, an interaction with the increase of *S. aureus* was observed in the chicken breast fillet samples which were treated with basil. This exceeded the established limit as being above the acceptable ($5x10^3$) having the parameters adopted by the National Sanitary Surveillance Agency (BRASIL, 2001), as a basis. Therefore, under the conditions of this experiment, this extract has shown little efficiency when it comes to bacterial inhibition.

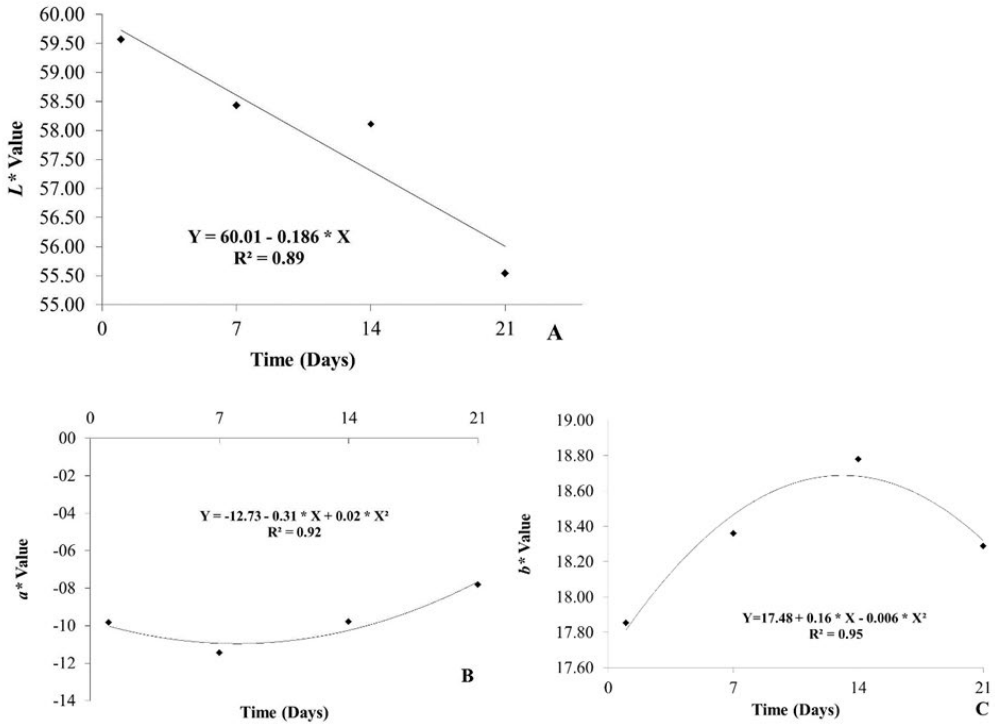

Figure 3 - Color L^* (A) a^* (B) and b^* (C) of chicken fillets marinated with different antioxidants during storage for 21 days at 5 °C.

The antimicrobial action of the phenolic compounds present in spices is due to their ability to penetrate the cell membrane causing damage to the plasma membrane of the microorganism (HAMMER & HEEL, 2012). In addition, the cell wall structure of Gram-positive bacteria allows hydrophobic molecules to cross cells and act both on the cell wall and on the cytoplasm (NAZZARO et al., 2013).

The use of 0.42% of basil essential oil on the inhibition of foodborne bacteria was tested by DI PASQUA et al. (2005), in which, was found little efficiency of basil oil against bacteria such as *Salmonella* and *E.coli O157: H7*. Different results were observed by BOSKOVIC et al. (2015), in which basil essential oil was evaluated in beef hamburgers, observed that the growth rate of *S. aureus* decreased. According to the authors, this essential oil may be used as an antibacterial agent.

In relation to rosemary and oregano, literature has reported efficiency in their use as antimicrobial, which agrees with the results obtained in the present study. PORTO et al. (2000) obtained results of *S. aureus* of $< 10^2$ in marinated chicken breast fillets with the addition of rosemary within 11 days of storage at 5 °C. SAHIN et al. (2004), using oregano essential oil on a series of bacteria of interest in food, observed that the essential oil was effective in inhibiting 10 from the 24 types of bacteria tested, particularly, the pathogenic bacteria *E. coli O157: H7*, *Salmonella* spp. and *S. aureus.*

AL-HIJAZEEN (2021) observed greater inhibition of *S. aureus* in cooked chicken meat and stored for seven days at 10 ºC when combining 150 ppm of oregano oil + 350 ppm of rosemary essential oil, different from this study that up to 21 days of storage the chicken breast fillets of all treatments were visibly deteriorated with the counting of *S. aureus* exceeding the acceptable limit adopted by the National Sanitary Surveillance Agency (BRASIL, 2001).

Using the indicators of microbiological contamination in this research, it was possible to observe the inhibitory action of natural extracts on the growth of *E. coli*, a pathogenic agent found regularly in meat. AHN et al. (2007) reports the antimicrobial

Table 2 - Microbiological count * (*Staphylococcus aureus*) of chicken fillets marinated with different antioxidants during storage for 21 days at 5 °C.

Treatments	Storage time (days)			
	0	7	14	21
BHT	3.4 x10^{1} aA	1.8 x10^{1} aA	2.4 x10^{1} bA	>10^{7} aB
Oregano	4.1 x10^{1} aA	1.3 x10^{1} aA	2.4 x10^{1} bA	>10^{7} aB
Rosemary	2.0 x10^{1} aA	1.3 x10^{1} aA	5.4 x10^{1} bA	>10^{7} aB
Basil	3.7 x10^{1} aC	3.1 x10^{1} aC	>10^{7} aB	>10^{7} aA
P value				
Antioxidant (A)				0.01849
Time (T)				<0.0001
A x T				<0.0001

[a-c]Means followed by the same lower case letters in a column and capital letters on the lines do not differ significantly by the Tukey test (P< 0.05). *Colony forming units (CFU)/g; BHT:butyl hydroxy toluene.

effect of plant extracts on *E. coli* and suggested that there is an increase in the efficiency of natural plant extracts when associated with the use of refrigeration.

Conversely, treatments were less effective in controlling *S. aureus*. RODRIGUEZ-CATURLA et al. (2012) stated that increasing the saline concentration in chicken breasts increases the resistance of *S. aureus* to refrigeration temperatures, as observed in this experiment. In a study evaluating the effects on the growth of *E. coli* and *S. aureus* of treatments with sodium chloride in meat, HAJMEER et al. (2004) observed that *E. coli* was less tolerant to sodium chloride than *S. aureus* in agreement with what was observed in this research.

LARA et al. (2003) reports the presence of viable *S. aureus* in jerked beef samples during the brine salting phase, and the processing becomes effective against the pathogen during the later dry salting and sun drying phases, where water activity drops to values of 0.75. PORTOCARRERO et al. (2002) inoculated *S. aureus* in samples of cured ham, which has water activity values close to those of marinated products. During storage, it was possible to isolate *S. aureus* in 75% of the samples.

According to LARA et al. (2003) only at high concentrations of sodium chloride, as in jerked beef, *S. aureus* has its viability inhibited. Staphylococci may have contaminated marinades through brine, making use of their halophilic capacity. The *S. aureus* counts reported in this experiment may show that under these experimental conditions the natural extracts of oregano and rosemary were effective in controlling this microorganism for more than 14 days and less than 21 days, while the addition of basil extract was effective in less than 14 days of storage. The inhibition of the microorganism's natural competitors by the concentration of sodium chloride, pH and the antimicrobial action of the additives may favor intense growth during storage, particularly under refrigeration conditions.

CONCLUSION

The use of rosemary, oregano and basil affects positively the oxidative stability of marinated chicken breast fillets and may be an alternative for replacing synthetic antioxidants. Basil extract is less efficient in inhibiting the development of *Staphylococcus aureus* in marinated chicken breast fillets when compared to others natural antioxidants tested in the present study. The viability of consumption of marinated chicken breast fillets with the inclusion of 0.2% of basil is within the limit of 7 to 14 days. For marinated chicken breast fillets with the addition of 0.01% BHT, rosemary and 0.2% oregano the consumption viability is more than 14 days, but less than 21 days of storage.

DECLARATION OF CONFLICT OF INTEREST

The authors declare no conflict of interest. The founding sponsors had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, and in the decision to publish the results.

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AUTHOR'S CONTRIBUTIONS

All authors contributed equally to the design and writing of the manuscript. All authors critically reviewed the manuscript and approved the last version.

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