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Taruma (*Vitex megapotamica*) extract: a promising natural antioxidant for frozen burgers

Extrato de Tarumã (*Vitex megapotamica*): um promissor antioxidante natural para hambúrgueres congelados

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ABSTRACT

This study aimed to evaluate the effect of the addition of taruma aqueous extract as a potential antioxidant to beef burgers during frozen storage, given that the fruit is abundant and easy to handle. Five formulations were made with the addition of different compounds with antioxidant characteristics as follows: negative control (no addition of antioxidants), positive control (0.1% sodium erythorbate), LIC (0.1% Licrezz™), EX (0.5% taruma extract), ERI/EX (blend of 0.05% sodium erythorbate and 0.25% taruma extract). The physicochemical and technological properties of the burgers were evaluated. The addition of taruma extract caused small changes (color, pH, TBARS) in the product's characteristics, during 180 days of frozen storage, with no changes in the reddish color, an important factor for marketing the product. Regarding the lipid oxidation assessed by the TBARS assay, although some changes were observed for all formulations, the burgers made with pure extracts showed a significant improvement of approximately 35% in the oxidative stability for the period studied. Thus, the results demonstrated the efficiency of taruma extract as a promising source of antioxidant agent and a potential natural color stabilizer for frozen beef burgers.
Keywords: antioxidants, color, burger, lipid oxidation, shelf life, *Vitex megapotamica*.

RESUMO

O objetivo do estudo foi avaliar o efeito da aplicação do extrato aquoso de tarumã como potencial antioxidante em hambúrgueres de carne bovina, durante o armazenamento sob congelamento, visto que a fruta se apresenta abundante e de fácil manuseio. Foram preparadas 5 formulações, nas quais diferentes compostos com características antioxidantes foram adicionados, sendo elas: controle negativo (sem adição de antioxidantes), controle positivo (eritorbato de sódio 0,1%), LIC (licrezz™ 0,1%), EX (extrato de tarumã 0,5%), ERI/EX (mistura de eritorbato de sódio 0,05% e extrato de tarumã 0,25%). Foram avaliadas algumas propriedades físico-químicas, características físicas e tecnológicas dos hamburgueres formulados. A adição de extrato de tarumã provocou pequenas alterações (cor, pH, TBARS) nas características do produto, durante 180 dias de armazenamento congelado, sem alteração da cor avermelhada, fator importante para a comercialização do produto. Em relação à oxidação lipídica avaliada pelo ensaio TBARS, embora tenham sido observadas algumas alterações para todas as formulações, os hambúrgueres elaborados com extratos puros apresentaram uma melhora significativa de aproximadamente 35% na estabilidade oxidativa para o período estudado. Sendo assim, os resultados demonstram a eficiência do extrato de tarumã como uma fonte promissora de antioxidante e potencial estabilizador de cor natural para hambúrgueres de carne bovina congelados.
Palavras-chave: antioxidantes, cor, hambúrguer, oxidação lipídica, armazenamento, *Vitex megapotamica*.

INTRODUCTION

Lipid oxidation is one of the main factors causing the deterioration of meat and meat products, due to their high fat contents. Oxidative reactions promote changes in the color, odor, and texture of meat products, directly affecting their quality. These changes are generally irreversible and can affect frozen products, such as burgers, as well as refrigerated foods (Pereira et al., 2017). In addition, they significantly contribute to the waste of animal-origin foods, whether processed or not.

Some alternatives can minimize and delay oxidative processes in meat products, such as completely removing oxygen from packaging and adding antioxidant compounds, thus preventing rancidity and discoloration, as well as other physicochemical changes (Lima et al., 2017). These antioxidant compounds can be synthetic, supplied by large multinational companies, or natural compounds, which is a promising and attractive alternative. This attractive characteristic is due to the nature of compounds derived from natural sources, which have lower toxicity when compared to their synthetic equivalents (Ribeiro et al., 2019). In addition, these natural antioxidants exhibit a more sustainable nature and lower environmental impact, as they come from renewable sources and are cultivated sustainably when compared to the chemical synthesis of synthetic antioxidants.

The growing interest in the application of natural compounds in meat products has led to an increase in demand for scientific studies on raw materials extracted from plants and/or fruits. For use in food, natural antioxidants must be safe, easy to homogenize, effective at low concentrations, free of odors, and flavors, thermostable, and economically viable (Milani et al., 2012).

Taruma (*Vitex megapotamica*) is a fruit found in several Brazilian regions and has a violet-black color when ripe, being a promising source of antioxidant compounds (Monteiro et al., 2024). However, few studies have been found in the scientific literature on the addition of these fruits to meat products (Caldeira et al., 2004; Vianna and Koehler, 2007; Cosmo et al., 2009).

In this context, this study aimed to evaluate the effect of the addition of taruma aqueous extract on the physicochemical and technological characteristics and stability during the frozen storage of beef burgers when compared with commercial antioxidants.

MATERIAL AND METHODS

The ripe taruma was harvested in areas belonging to the Federal Institute of Education, Science and Technology of Rio Grande do Sul - IFSR, Sertão campus, in the city of Sertão/RS, Brazil (Latitude 28° 2' 26" S, Longitude 52° 16' 25" O). The fruit was cleaned and sanitized before use in the experiment, as reported by Monteiro et al. (2024).

The commercial antioxidants sodium erythorbate and Licrezz™ (a product extracted from *Glycyrrhiza glabra* roots, popularly known as licorice) were supplied by ICL Aditivos e Ingredientes LTDA. The raw materials beef shoulder, beef fat, salt, dehydrated onion powder, dehydrated garlic powder, black pepper powder, and textured soy protein were purchased from local markets in Pinhalzinho, Santa Catarina, Brazil.

The taruma extract was prepared as described by Rufino et al. (2007), with modifications. Water was used as the extraction solvent in a sample-to-solvent ratio of 1:30 (w/v). The mixture was homogenized and the pH was adjusted to 5.0 using 0.1 M citric acid or 0.2 M dibasic sodium phosphate solutions using a pH meter (mPA210, MS Technopon, Brazil). The mixture was stirred in an orbital shaker (Luca-223, Lucadema, Brazil) at 100 rpm for 3 hours at 80 °C. The suspended solids were then filtered out and the filtered extract was wrapped in aluminum foil and stored under refrigeration (5 °C) in a conventional refrigerator (Electrolux, Brazil) until use within 24 h.

The burgers were made according to the methodology described by Ferreira et al. (2019), and the complete formulations are shown in Table 1.

The burgers were made in triplicate batches, with the addition of ingredients in the following order: beef and beef fat ground in an industrial grinder with an 8 mm disk (MSI-10, Becker, São Paulo, Brazil), soy protein, salt, dehydrated onion powder, dehydrated garlic powder, black pepper powder, antioxidant agents, and water. For better solubilization, the antioxidants sodium erythorbate and Licrezz™ were dissolved in the water content used in the formulation, while taruma was used

Table 1. Beef burger formulations made with different antioxidant agents.

Ingredients (%)	Formulations				
	CONT.N	CONT.P	LIC	EX	ERI/EX
Beef	75.0	75.0	75.0	75.0	75.0
Beef fat	7.4	7.4	7.4	7.4	7.4
Salt	1.5	1.5	1.5	1.5	1.5
Dehydrated garlic powder	0.1	0.1	0.1	0.1	0.1
Dehydrated onion powder	0.05	0.05	0.05	0.05	0.05
Black pepper powder	0.05	0.05	0.05	0.05	0.05
Textured soy protein	4.0	4.0	4.0	4.0	4.0
Water	11.9	11.8	11.8	11.4	11.6
Sodium erythorbate	-	0.1	-	-	0.05
Licrezz™	-	-	0.1	-	-
Taruma extract	-	-	-	0.5	0.05/0.25

Formulations: CONT.N: negative control, no addition of antioxidants; CONT.P: positive control, sodium erythorbate (0.1%); LIC: Licrezz™ (0.1%); EX: taruma extract (0.5%); ERI/EX: sodium erythorbate + taruma extract (0.05%/0.25%).

in the form of an aqueous extract. They were then mixed with the burgers by hand for 10 minutes and the burgers were shaped in stainless steel molds with a diameter of 8 cm (50 g of batter). The burgers were then unmolded, packed in polyethylene bags, and stored at -12 °C in a conventional freezer (Consul, Brazil) until analysis.

The proximate composition of three burger samples (n=9) from each batch was determined for moisture content (method 925.45 (b)); fat content by the Soxhlet method (method 920.39 (c)); protein (method 920.152) with a conversion factor of 6.25; and ash content (method 940.26) according to Association of Official Analytical Chemists (2016).

The stability of the burgers was analyzed during frozen storage, in triplicate (n=9), at 1, 30, 60, 150, and 180 days of storage for pH, color, and thiobarbituric acid reactive substances (TBARS).

The pH was measured using a bench pH meter (mPA210, MS Technopon, Brazil) as reported by Fernández-López et al. (2006). The objective color of the samples was determined by measuring reflectance using a CR-410 Minolta colorimeter (HunterLab, Brazil), according to the manufacturer's instructions, using the CIELAB system. The color variation (ΔE) was calculated by the variation of the L*, a* and b* parameters, according to Lopes et al. (2005).

The TBARS index was determined using the spectrophotometric method described by Jo and Ahn (1998), with modifications. For that, 5 g of sample was mixed with 30 mL of 7.5% trichloroacetic acid (TCA) solution. The mixture was filtered through qualitative filter paper (Qualy 12.5 cm, J. Prolab, Brazil). A 2 mL aliquot of the filtrate was transferred to a test tube with a lid and 2 mL of 0.02 M thiobarbituric acid (TBA) solution was added. The tubes were heated in a digital water bath (SSD 5L, Solidsteel, Brazil) for 20 minutes at 100 °C, cooled to room temperature using a cooled water bath, and the absorbance was read at 532 nm in a spectrophotometer (80 SA, Femto, Brazil). All analyses were performed in triplicate and the results were expressed in mg of MDA.kg^{-1} of sample.

The technological parameters of the burgers were determined on day 60 of storage for shear force, water retention capacity, cooking yield, and shrinkage. For these analyses, the burgers were thawed for 12 hours at 4 °C in a refrigerator (Electrolux, Brazil) until analysis.

The shear force (N) required to cut the samples was determined using a CT3 texture analyzer (Brookfield) with a Warner Bratzler blade, a speed of 5 mm.s^{-1}, a trigger load of 1.0 N, and 50% depth. The analysis was carried out on the raw burgers measuring 1.0 cm wide, 4.0 cm long and 0.8 cm high, with adaptations (Abularach et al., 1998).

To determine the water retention capacity, the samples (10 g) were cut to a standard size of 3.0 × 3.0 × 0.8 cm, placed on qualitative filter paper (Whatman 40, 125 mm in diameter), previously dried, between two acrylic plates, and a 5 kg cylinder was placed over them for 10 min. The amount of water lost was determined in the resulting sample, as described by Bertolo et al. (2022). The cooking yield (CY) was determined by the ratio between the mass of the cooked sample and the mass of the raw sample. The shrinkage percentage (S) was determined using a caliper, as reported by Seabra et al. (2002).

Statistical analysis was carried out using STATISTICA 14 Trial software (Statsoft), and analysis of variance (ANOVA) and comparison of means by Tukey's test at 5% significance level.

RESULTS AND DISCUSSION

No significant differences were observed for moisture, fat, protein, and ash contents between the samples (Table 2), thus the taruma aqueous extract did not alter the proximate composition of the product, indicating a promising use of this extract in beef burger formulations. In addition, the results are in line with the recommendations of the current legislation known as the Technical Regulation for the Identity and Quality of Burgers (Brasil, 2022), which sets limits of a maximum of 25% fat and a minimum of 15% protein.

Regarding the color parameters (Table 3), a reduction in L* value was observed between days 1 and 180 of storage, except for EX, which showed no significant

Table 2. Proximate composition of beef burgers made with different antioxidant agents.

Parameter (%)	Formulations				
	CONT.N	CONT.P	LIC	EX	ERI/EX
Moisture	72.42 ± 0.82^{a}	72.08 ± 0.35^{a}	72.03 ± 0.62^{a}	72.00 ± 0.44^{a}	72.66 ± 0.87^{a}
Protein	19.12 ± 0.41^{a}	19.67 ± 0.50^{a}	19.11 ± 0.46^{a}	18.73 ± 0.29^{a}	18.56 ± 0.87^{a}
Fat	5.68 ± 0.34^{a}	5.16 ± 0.08^{a}	5.30 ± 0.20^{a}	5.42 ± 0.12^{a}	5.56 ± 0.28^{a}
Ash	2.67 ± 0.17^{a}	2.70 ± 0.26^{a}	2.79 ± 0.15^{a}	2.63 ± 0.09^{a}	2.71 ± 0.06^{a}

Values expressed as mean ± standard deviation. Formulations: CONT.N: negative control with no addition of antioxidants; CONT.P: positive control: sodium erythorbate (0.1%); LIC: Licrezz™ (0.1%); EX: taruma extract (0.5%); ERI/EX: sodium erythorbate + taruma extract (0.05%/0.25%). Averages followed by the same letter on the same line do not differ statistically by Tukey's test at a 5% significance level.

Table 3. Instrumental color parameters L*, a*, b*, and ΔE during frozen storage of burgers made with different antioxidant agents.

Parameter	Formulation	Days				
		1	30	60	150	180
L*	CONT.N	36.48 ± 0.87^{aA}	33.12 ± 0.05^{bAB}	31.39 ± 0.12^{dA}	32.98 ± 0.58^{bcA}	31.64 ± 0.15^{cdA}
	CONT.P	32.99 ± 1.92^{aB}	31.97 ± 0.32^{aB}	31.90 ± 1.50^{aA}	30.46 ± 0.72^{bBC}	28.88 ± 0.66^{bBC}
	LIC	32.55 ± 1.02^{aB}	32.54 ± 0.50^{aB}	30.69 ± 0.94^{abA}	28.15 ± 2.58^{bC}	29.44 ± 0.33^{bBC}
	EX	32.26 ± 1.60^{aB}	32.19 ± 1.13^{aB}	32.05 ± 0.82^{aA}	31.83 ± 0.46^{aAB}	30.14 ± 0.69^{aAB}
	ERI/EX	35.40 ± 3.32^{aAB}	34.65 ± 0.15^{aA}	32.70 ± 1.18^{abA}	31.68 ± 0.80^{bAB}	28.21 ± 0.75^{cC}
a*	CONT.N	6.39 ± 0.07^{aB}	6.70 ± 0.12^{aC}	5.57 ± 0.13^{bB}	4.78 ± 0.08^{cB}	4.75 ± 0.48^{cB}
	CONT.P	8.12 ± 0.83^{aAB}	9.06 ± 0.91^{aA}	7.64 ± 0.31^{abA}	5.89 ± 0.26^{cB}	6.48 ± 0.00^{bcA}
	LIC	8.24 ± 0.90^{aA}	7.59 ± 0.55^{abBC}	6.14 ± 0.74^{bCB}	5.68 ± 0.56^{cB}	5.64 ± 0.14^{cAB}
	EX	7.92 ± 0.77^{aAB}	7.53 ± 0.70^{aBC}	5.85 ± 0.46^{bB}	5.67 ± 0.15^{bB}	5.77 ± 0.11^{bAB}
	ERI/EX	9.22 ± 0.45^{aA}	8.23 ± 0.14^{abAB}	7.49 ± 0.01^{bA}	7.85 ± 0.80^{abA}	4.95 ± 0.97^{cB}
b*	CONT.N	10.37 ± 0.35^{bC}	9.62 ± 0.08^{cA}	10.50 ± 0.26^{bAB}	11.42 ± 0.01^{aA}	9.40 ± 0.05^{cA}
	CONT.P	12.58 ± 0.16^{aA}	9.72 ± 0.63^{bcA}	11.04 ± 0.73^{bA}	9.51 ± 0.40^{cB}	9.26 ± 0.33^{cAB}
	LIC	11.02 ± 0.38^{aBC}	10.93 ± 0.65^{aA}	9.70 ± 0.51^{bB}	10.11 ± 0.08^{abB}	8.52 ± 0.17^{cBC}
	EX	10.53 ± 0.27^{aB}	10.00 ± 0.76^{bA}	9.75 ± 0.31^{bB}	9.50 ± 0.29^{bB}	8.35 ± 0.26^{cC}
	ERI/EX	10.53 ± 0.27^{aC}	9.73 ± 0.57^{abA}	10.44 ± 0.22^{aAB}	10.02 ± 0.95^{cB}	8.73 ± 0.48^{bABC}
ΔE	CONT.P	4.48	2.62	2.20	3.29	3.26
	LIC	4.39	1.64	1.21	5.01	2.53
	EX	4.67	1.30	1.03	2.37	2.10
	ERI/EX	3.03	2.17	2.33	3.59	3.49

Formulations: CONT. N.: negative control with no addition of antioxidants; CONT.P.: positive control - sodium erythorbate (0.1%); LIC: Licrezz™ (0.1%); EX: taruma extract (0.5%); ERI/EX: sodium erythorbate + taruma extract (0.05%/0.25%). Different lowercase letters in the line indicate statistically significant differences ($p \leq 0.05$) for the same sample at different storage periods. Different uppercase letters in each column indicate statistically significant differences ($p \leq 0.05$) between samples from the same storage period.

difference, thus the addition of the taruma extract may have inhibited the darkening of the burgers. Burger browning is due to the oxidation of myoglobin, leading to transformations in the pigment oxymyoglobin (red) into metmyoglobin, forming a grayish-brown color (Utrera et al., 2014; Viana et al., 2020). Borella et al. (2019) reported no color changes in burger samples made with the addition of rosemary extract at concentrations of 0.03% and 0.06% stored for 120 days. These are relevant results, which suggest that the addition of natural extracts can preserve processed meat products for medium to long periods of frozen storage.

All burgers showed a tendency towards a reduction in red color (parameter a*, Table 3), which can be considered a negative effect, affecting the product's appearance and consumers' acceptance (Vidal and Prestes, 2014). Probably, the discoloration is due to the processing conditions since beef is processed together with seasonings and may present initial oxidation processes, which leads to color changes (Utrera et al., 2014). In turn, freezing favors a brownish hue due to the difficulty in penetrating O_2 and the conduction of electrolytes that induce the production of metmyoglobin. The increase in this pigment leads to a decrease in the a* values (Ordóñez, 2005; Hernández Salueña et al., 2019; Zahid et al., 2020). Gahruie et al. (2017) also reported a decrease in a* values of burgers made with the addition of natural extracts of cinnamon and rosemary.

All samples showed a slight reduction ($p \leq 0.05$) in the b* parameter (Table 3) throughout storage. Borella et al. (2019) reported that differences in b* values during storage are also due to the oxidation process. In the present study, the antioxidant agents may have impaired lipid oxidation since there was no increase in b* values for all samples studied. Concerning ΔE, all samples showed visible color differences on day 1 of storage, with no perceptible changes on days 30 and 60. At day 150 of storage, only the sample EX showed no visible difference, while the positive control and ERI/EX samples showed a visible change in color on the last day of storage. Therefore, only the sample EX presented no ΔE perceptible to the human eye throughout the 180 days of storage. The images can be seen in Figure 1.

Concerning the pH values (Figure 2) of the different formulations, there was no significant difference between days 1 and 60 of storage. The opposite behavior was observed by Feihrmann et al. (2022), who studied the addition of yerba mate (*Ilex paraguariensis*) extract to frozen beef burgers and reported a decrease in the pH values after storage for 60 days under freezing conditions. On the other hand, significant changes in pH were observed ($p \leq 0.05$) from days 150 and 180 of frozen storage. The pH values, which were close to 6 until day 60, reached values close to 6.1 on day 150 and above 6.2 on day 180 of storage. This increase in pH may be due to the alkalinization of the meat, caused by small increases in ammonia nitrogen levels from the degradation of proteins and amino acids by Gram-negative bacteria (Mokhtar et al., 2014; Mancini et al., 2020).

According to Geesink et al. (2000), pH is an important meat quality parameter, as it is related to color, water retention capacity, and tenderness, among other factors. Galvão (2006) reported that factors such as the type and quantity of raw materials used in the formulation and even the cooking process of the burgers can influence the pH of the product.

The TBARS assay (Figure 3) showed significant differences ($p \leq 0.05$) for the formulations throughout storage, with a significant increase in values after 180 days, which was expected due to the formation of oxidation compounds. The results of this study showed that the use of natural antioxidants (EX and LIC) was effective in delaying oxidation in the last analysis period (180 days) with 30% and 40%, lower concentrations (mg of $MDA.kg^{-1}$ of sample) respectively, when compared to the negative control. Paiva et al. (2021) studied the addition of LIC to alligator meat nuggets and reported that this antioxidant was the most effective in inhibiting lipid oxidation during 120 days of frozen storage, confirming the effectiveness of natural antioxidants and their technological advantage over synthetic antioxidants. A similar result was also found for the taruma extract in this study.

As reported by Al-Kahtani et al. (1996), values less than 3 mg of $MDA.kg^{-1}$ of the sample are sufficient to prevent lipid oxidation in meat products. Thus, the frozen

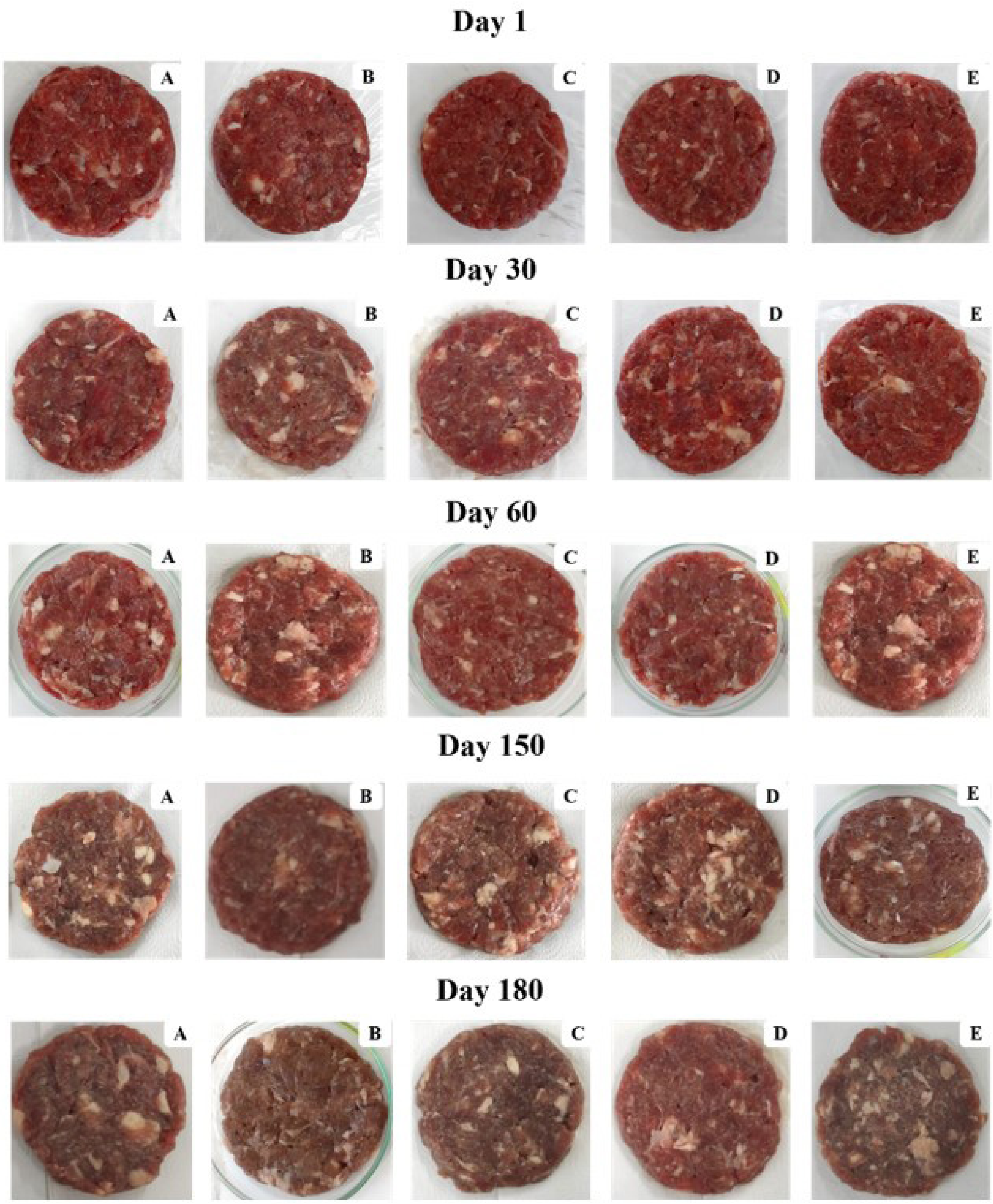

Figure 1. Beef burgers made with different antioxidant agents: negative control with no addition of antioxidants (A), positive control - 0.1% sodium erythorbate (B), 0.1% Licrezz™ (C), 0.5% taruma extract (D), sodium erythorbate + taruma extract (0.05%/0.25) (E), during frozen storage.

burgers of this study showed no signs of oxidation since none of them had values higher than 3 mg of MDA.kg^{-1}.

No significant differences were observed in cooking yield (CY), shrinkage percentage (S), water retention capacity (WRC) and shear force (SF) between the formulations (Table 4).

Higher CY values result in lower losses of hamburger mass after cooking, therefore all the formulations showed good results. Despite the promising results of this test, beef, and beef products tend to suffer loss of liquids during cooking, denaturation of proteins, melting of fats and partial shrinkage of meat fibers, thus low CY values are expected (Choi et al., 2009).

The results of the shrinkage percentage (S) showed that the addition of antioxidants led to no changes in the size of the burgers after cooking. The WRC

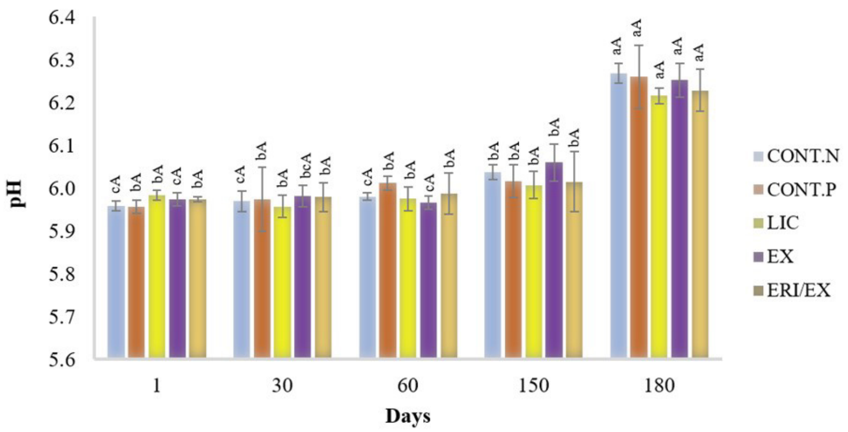

Figure 2. pH values of beef burgers made with different antioxidant agents during frozen storage. Formulations: CONT.N.: negative control with no addition of antioxidants; CONT.P.: positive control - sodium erythorbate (0.1%); LIC: licrezzTM (0.1%); EX: taruma extract (0.5%); ERI/EX: sodium erythorbate + taruma extract (0.05%/0.25%). Different lowercase letters show a significant difference (p≤0.05) throughout storage for the same formulation. Different uppercase letters show a significant difference (p≤0.05) between the formulations on the same day of storage.

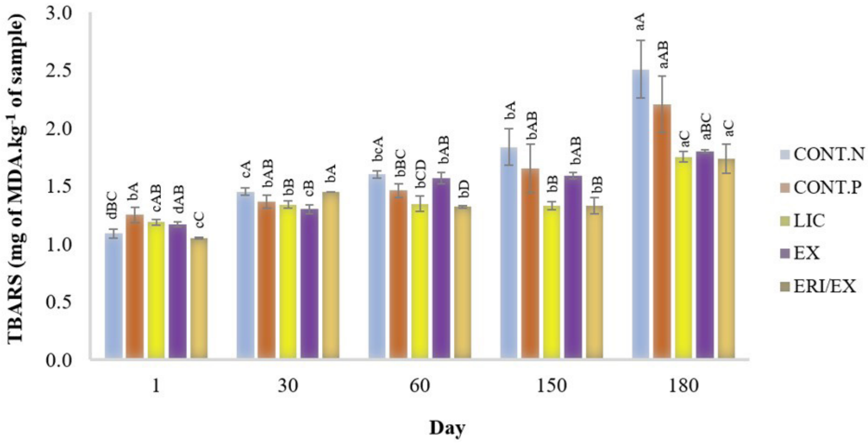

Figure 3. Lipid oxidation (TBARS) of beef burgers made with different antioxidant agents during frozen storage. Formulations: CONT.N.: negative control with no addition of antioxidants; CONT.P.: positive control - sodium erythorbate (0.1%); LIC: licrezz™ (0.1%); EX: taruma extract (0.5%); ERI/EX: sodium erythorbate + taruma extract (0.05%/0.25%). Different lowercase letters show a significant difference (p≤0.05) throughout storage for the same formulation. Different uppercase letters show a significant difference (p≤0.05) between the formulations on the same day of storage.

Table 4. Technological properties of beef burgers made with different antioxidant agents during 60 days of frozen storage.

Parameters	Formulation				
	CONT.N	CONT.P	LIC	EX	ERI/EX
CY (%)	78.23 ± 0.53^{a}	78.05 ± 0.20^{a}	78.23 ± 0.41^{a}	78.56 ± 0.09^{a}	78.58 ± 0.49^{a}
S (%)	13.56 ± 0.50^{a}	12.94 ± 1.07^{a}	12.64 ± 0.71^{a}	13.14 ± 1.52^{a}	12.08 ± 0.18^{a}
WRC (%)	86.15 ± 0.29^{a}	85.51 ± 0.43^{a}	85.67 ± 0.82^{a}	87.15 ± 0.59^{a}	86.84 ± 0.88^{a}
SF (N)	5.71 ± 0.20^{a}	5.42 ± 0.40^{a}	5.71 ± 0.26^{a}	5.19 ± 0.15^{a}	5.54 ± 0.43^{a}

Mean ± standard deviation. CY: cooking yield; S: shrinkage percentage; WRC: water retention capacity; SF: shear force. Formulations: CONT. N.: negative control with no addition of antioxidants; CONT.P.: positive control - sodium erythorbate (0.1%); LIC: Licrezz™ (0.1%); EX: taruma extract (0.5%); ERI/EX: sodium erythorbate + taruma extract (0.05%/0.25%). Different lowercase letters in each row indicate statistically significant differences (p≤0.05).

determines visual acceptability, weight loss, cooking yield, as well as the sensory characteristics of meat and meat products (Warner, 2017). In the present study, the WRC values ranged from 87.15 - 85.51%, with similar results for all samples, demonstrating that the addition of taruma extract did not interfere with this characteristic. Higher WRC values represent better product acceptability.

No significant differences were observed for SF between the samples. Tenderness is a characteristic related to SF, which is directly associated to WRC since the greater the water retention, the lower the shear force used to cut the meat fragment (Zeola et al., 2007), which corroborates the results of this study (Table 3). The formulation made with the addition of taruma extract (EX) showed the lowest SF value.

The addition of taruma extract did not interfere with the technological characteristics of the burgers of this study. The formulations made with the addition of the extract (EX, ERI/EX) showed promising and significant results for cooking yield (CY), maintaining or even improving the technological characteristics of the final product.

CONCLUSION

The addition of the taruma powder extract to beef burger formulations did not affect the proximate composition, shear force, shrinkage percentage, water retention capacity, and pH of the samples. Although all formulations showed changes in the TBARS values due to lipid oxidation during storage, the natural antioxidants (LIC and EX) proved to be relatively efficient in the oxidative stability of beef burgers during 180 days of frozen storage. Therefore, the taruma extract has proven to be an effective alternative as a potential natural antioxidant in processed beef products.

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