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Determining the Effectiveness of Rosemary Essential Oil on the Shelf Life of Ground Beef Under Different Lighting Conditions

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Meet the Student-Author

Jordan Looper

In May of 2023, I graduated Summa Cum Laude with a degree in Animal Science and Spanish. I am from Greenwood, Arkansas, where I attended Greenwood High School. During my time at the University of Arkansas, I was a member of the Block and Bridle club, where I served as secretary and president, a member of the Meat Science Quiz Bowl Team, a member of the Animal Science Quadrathlon Team, and an Animal Science REPS member. I was also able to gain hands-on experience working in the Food and Poultry Science labs. Outside of class, I taught the adult Sunday school class at my home church and often volunteered with Apple Seeds Teaching Farm. I will be attending Kansas State University in the fall of 2023 to work on a master's degree in Meat Science. I intend to continue my education and pursue a career in education and research at the university level. I have always been interested in the food industry, but I had no idea of the scope of its impact until I began working on this project. It has been an honor to work with my honors mentor, Dr. Kelly Vierck, and her graduate students, Lizzi Neal and Katie Boatright, as well as Dr. Janeal Yancey and Dr. Derico Setyabrata. Without them, I would not have found my passion for meat science and a career I love building each day.

Jordan using the homogenizer to blend samples as a step in the thiobarbituric acid reactive substances assay.

Research at a Glance

- Color is one of the most important factors consumers use in determining product desirability.
- Antioxidants are used to help extend the shelf life of a variety of products, including produce and meat products.
- Lighting intensity and antioxidant manipulation are two possible means of increasing the shelf life of ground beef.

Determining the Effectiveness of Rosemary Essential Oil on the Shelf Life of Ground Beef Under Different Lighting Conditions

Jordan T. Looper and Kelly R. Vierck†*

Abstract

This study determined the effectiveness of rosemary extract on the shelf life of ground beef patties under different retail display conditions. Ground beef patties were produced from an 85%:15% blend (lean:fat). Patties were formed from batches of control or amended with rosemary extract. Patties were individually packaged using overwrap. Groups were assigned into one of two lighting groups (3000K and 3500K). Patties were placed in a simulated retail display for 5 d under continuous lighting and rotated once a day. Lipid oxidation and color samples were taken each day. Relating to lipid oxidation, there was no three-way interaction between display day, antioxidant, and light intensity ($P > 0.05$). There was an interaction observed between antioxidant and day ($P < 0.0001$). Relating to color spectrometry, L* values presented an interaction between antioxidant and lighting intensity ($P = 0.0029$). A two-way interaction between day and antioxidant ($P = 0.0003$) was also shown in a* values and b* values ($P = 0.0008$). Chroma values displayed an interaction between antioxidant and day ($P = 0.0008$). The hue data concluded similar results ($P = 0.0008$); there was an interaction observed between antioxidant × day ($P < 0.0001$). These results indicate that color instability and degradation can be prevented with the introduction of antioxidants and the reduction of retail display days. These data suggest that antioxidants reduce lipid oxidation regardless of light temperature. Antioxidants can still be used to extend shelf life and improve color stability in ground products.

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† Kelly R. Vierck, the faculty mentor, is an Assistant Professor in the Department of Animal Science.

Introduction

The use of natural alternatives as food additives to improve taste, texture, appearance, and shelf-life has become increasingly popular in recent years, both from a consumer and food industry perspective. Research into the topic of bacterial growth, when exposed to natural oils, has been occurring since the 1970s, and with the growth in popularity and availability of natural oils in the last decade, inquiries into the role and function of these oils in the food industry have increased. Essential oils and naturally growing plants have been shown to act similarly to some current synthetic products that extend shelf life when used with fresh produce but provide negative olfactory responses due to unique odors and tastes associated with these oils (Rodríguez et al., 2015). These plant-based oils, however, are limited by these flavor compounds resulting in certain antioxidants being better suited for specific food groups than others, and their synthetic counterparts provide a more cost-efficient and more stable product that consistently performs higher (Pokorný, 2007). Studies have shown the potential for synthetic antioxidants to be harmful to health, and although the numbers are extremely low, adverse reactions to these additives are possible; however, natural alternatives cannot be determined to be entirely safe either (Randhawa and Bahna, 2009; Pokorný, 2007). In recent years, research performed during animal processing has been underdeveloped, yet reports on the effects of oils utilized during nutritional supplementation of live animals and during processing practices have grown significantly. This form of shelf-life extension could potentially provide a multitude of benefits for consumers, including decreased prevalence of foodborne illness, alternatives to synthetic antioxidants, and the use of a cleaner label for consumers. While the driving force for more natural alternatives primarily appears to stem directly from the consumer side, potential outcomes of research within the beef industry, or other food and beverage sectors, could provide novel and impactful results for a product that meets consumer needs and desires (McDonnell et al. 2013).

The goals of this study included determining the effect of essential oils on ground beef storage in conjunction with alterations in lighting intensity. The causality that was expected was that an extension of shelf life for ground beef treated with essential oils in combination with a lower light intensity would result after a common period in retail display. Through previously conducted research, the positive correlation between shelf life and essential oil, as well as between shelf life and lower lighting intensity, implies the possibility of synergism when the two are combined.

Materials and Methods

Ground beef was purchased locally with an 85% lean and 15% fat ratio, fine ground through a 0.953 cm plate, and separated into 151.2 g patties (n = 64) using the Hollymatic Super Patty Machine. During grinding, Kalsec® Oleoresin Rosemary, Herbalox® Brand XT-25 was added with a concentration of 0.20% (Keokamnerd et al., 2008) to half the beef. Patties were assigned randomly to one of two treatments, a control group and a group treated with essential oil. Patties were individually packaged in foam trays with an oxygen-permeable polyvinyl wrap. Patties, within antioxidant treatment, were assigned randomly to two different lighting temperatures (3000 K or 3500 K) in retail placement. Six batches were created with three antioxidant batches per antioxidant treatment. A completely randomized split-plot design was used. One batch served as the whole plot, and lighting served as a whole plot. Ground patties were subjected to a simulated retail display for five days under continuous light-emitting diode (LED) lighting at 4 °C. Patties were rotated once each day following thiobarbituric acid reactive substances (TBARS) and color data collection. These patties were rotated randomly within the shelving of the display case, moving internally in the shelves as well as levels in the case. Ground beef patties were displayed in the simulated retail case for five days, with the control and antioxidant treatments assorted randomly throughout the two separate lighting cases.

During each day of retail display, the instrumental color of patties was determined using the Hunter Lab MiniScan EZ spectrophotometer. A randomly generated list of the patties was used to determine the patties used for each day of color. The L*, a*, and b* values were taken to determine lightness, redness, and yellowness, respectively; the hue values were taken to measure the vividness; and the chroma values were taken to determine saturation (King et al., 2023). Hue was calculated by taking the arctangent of the b* values divided by the a* values, while chroma was calculated by squaring both a* and b* values and taking the square root of the sum, according to the American Meat Science Association Guidelines (King et al., 2023). Three measurements were taken per patty and averaged together to provide an overall color measurement for each patty. Subsets of patties were frozen for days 1–5 following placement in retail display.

Each sample was then thawed for 10 to 12 hours to 5 °C, placed in liquid nitrogen, and powdered using a Nutribullet blender. A randomly generated list of the patties was used to determine the patty sample collected for analysis. A 10-g sample was weighed into a 50-mL conical tube, and TBARS, an assay measuring malondialdehyde as a representation of lipid oxidation, were analyzed through the modified procedure of Buege and Aust (1978) as described by Luque et al. (2011). A standard curve for the assay was run for each day of testing. Samples were blended with 30 mL of deionized water and then centrifuged. Two mL of the supernatant was removed and added to a 50-mL centrifuge tube with the

trichloroacetic acid reagent and butylated hydroxyanisole. Samples were heated, cooled, and centrifuged. Two 1-mL samples were added to a 48-well plate and then analyzed.

Data were analyzed as a split-split plot design, with batch serving as the whole plot and patty serving as the subplot. Fixed effects in the model were lighting temperature, antioxidant treatment, and day of display. The Kenward-Rogers adjustment was used with all analyses. Statistical differences were considered significant at $\alpha \leq 0.05$.

Results and Discussion

There was no three-way interaction between display day, antioxidant, and light temperature ($P > 0.05$), as well as no interactions between display day and light temperature ($P > 0.05$), and antioxidant and lighting temperature ($P > 0.05$) on TBARS. No effect of lighting temperature was observed ($P > 0.05$). There was an interaction observed between antioxidant and day ($P < 0.0001$) (Fig.1). Overall, a larger separation between control and antioxidant was shown through each progressive day of display, expressing a linear response of lipid oxidation in the control group, while the treated antioxidant group remained relatively consistent. Additionally, a main effect of antioxidant ($P < 0.05$) and display day ($P < 0.05$) were observed. The patties with the antioxidant treatment expressed lower lipid oxidation than the control patties, regardless of lighting intensity ($P < 0.05$). Furthermore, a reduction in display day yielded a net reduction in lipid oxidation, regardless of lighting temperature or antioxidant supplementation ($P < 0.05$).

There were no three-way interactions observed for any of the color traits evaluated ($P < 0.05$). There was no interaction between day and antioxidant presented in L* values ($P > 0.05$). There was an interaction between antioxidant and light ($P = 0.0029$), indicating that lightness value increases as lighting intensity increases (Fig. 2). When antioxidant treatment was included, there was no difference between the groups at 3500 K; however, at 3000 K, antioxidants showed an increase in lightness. There was a main effect of day ($P < 0.0001$) with a predominate linear decline in L* as day progressed, with the exception of day 0, implying that the addition of the oleoresin antioxidant could have played a role in the lower lightness value.

There was also no interaction between day and lighting intensity ($P > 0.05$) or between lighting intensity and antioxidant ($P > 0.05$) in a* values. A two-way interaction was found between day and antioxidant ($P = 0.0003$) (Fig. 3). The antioxidant group consistently had higher redness throughout the trial, with each day decreasing in value; however, the day 3 control values were the same for day 4 values for the patties with antioxidants, implying that with the antioxidant treatment, a day of retail display may be gained in terms of redness.

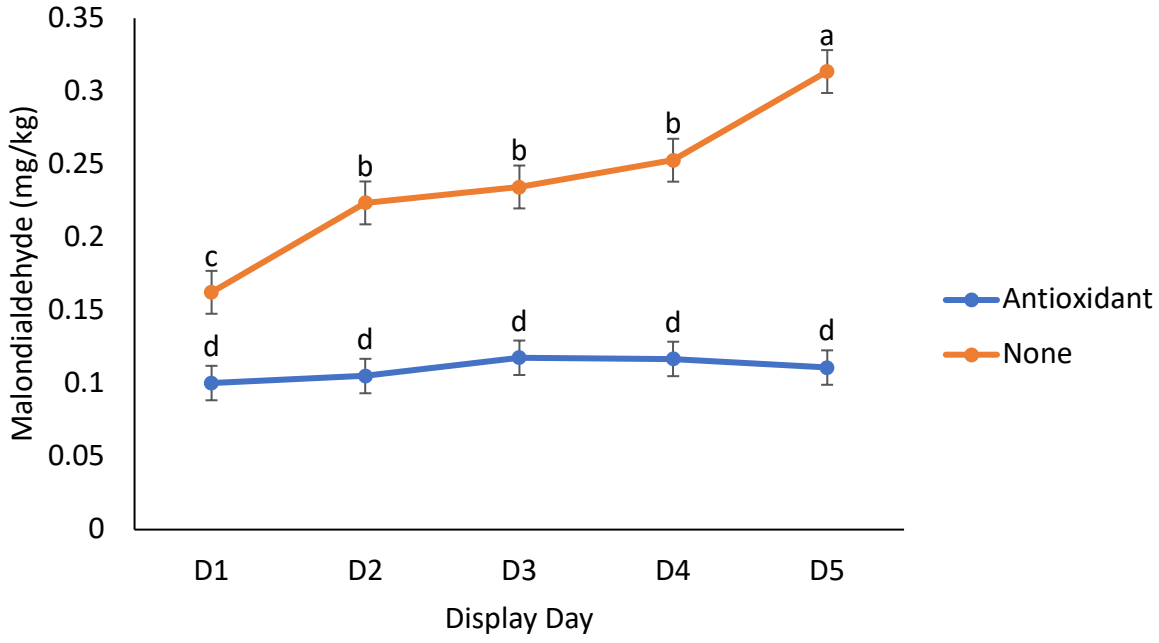

Fig. 1. Two-way interaction of antioxidant/no antioxidant treatment groups and display day on malondialdehyde concentration ($P < 0.0001$). Least square means without a common letter differ ($P < 0.05$).

There was also no interaction between day and light ($P > 0.05$) or between light and antioxidant ($P > 0.05$) in b* values. A two-way interaction was found between day and antioxidant ($P = 0.008$) (Fig. 4). On day 3, the control treatments had similar b* to the antioxidant treatments on day 4. This trend can be seen throughout the rest of the study, with the antioxidant group reaching similar yellowness one day behind the treatment group. A main effect of lighting temperature was also expressed ($P = 0.0234$), stating that lower lighting intensity resulted in higher yellowness regardless of day or antioxidant.

There was no interaction between day and light ($P > 0.05$) or between antioxidant and light; however, a hue angle day and antioxidant interaction was present ($P = 0.0008$) (Fig. 5). On day 3, control patties had similar values as antioxidant patties on day 4 and continued in a similar pattern until the end of the trial. This once again presents the notion that with the introduction of antioxidants, there could

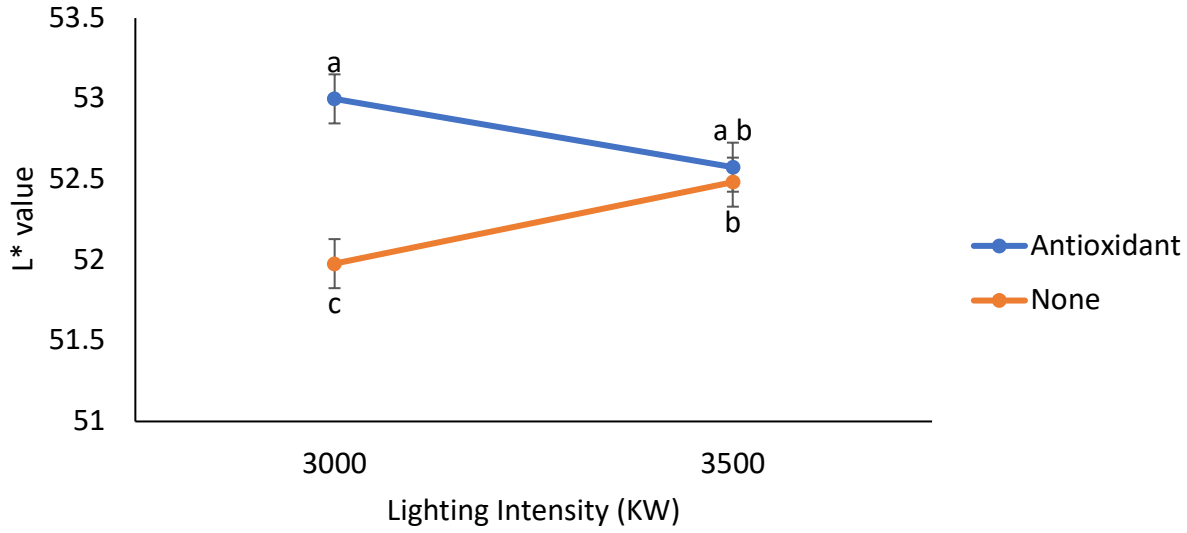

Fig. 2. Two-way interaction of antioxidant/no antioxidant treatment groups and 3000K/3500K lighting intensity on L* value ($P = 0.0029$). Least square means without a common letter differ ($P < 0.05$). L* is a measurement of lightness on a scale of 0–100 with white representing 100.

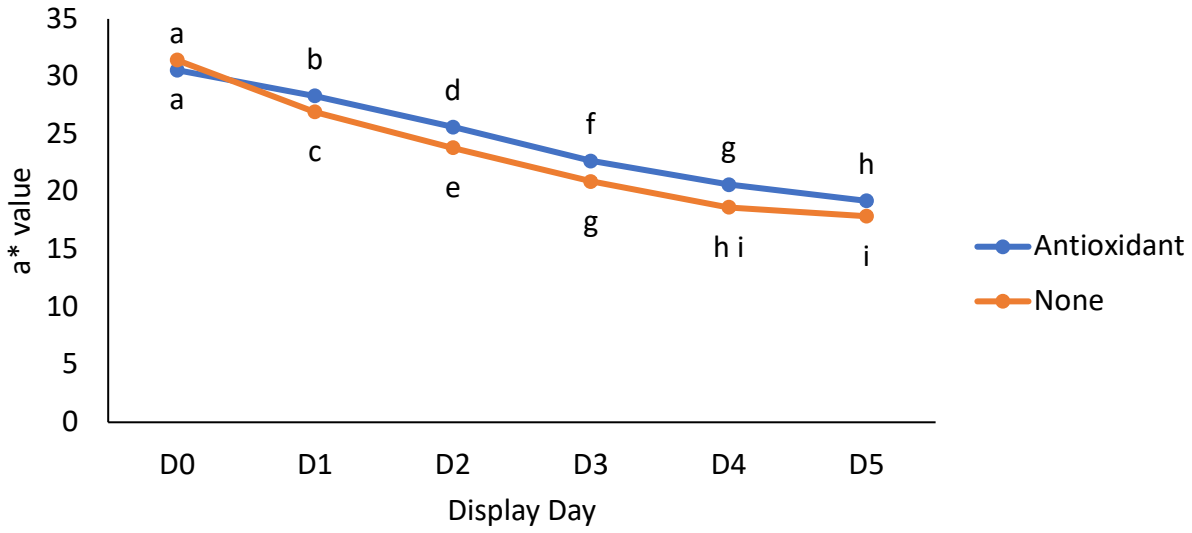

Fig. 3. Two-way interaction of antioxidant/no antioxidant treatment groups and display day on a* value ($P = 0.0003$). Least square means without a common letter differ ($P < 0.05$). a* is a measurement of redness with positive values indicating red and negative values indicating green.

be an increase of one day in the display life of the product in regard to the prevention of instrumental discoloration.

There was no main effect of light found ($P > 0.05$) regarding chroma. There was no interaction between day and light ($P > 0.05$) or between antioxidant and light ($P > 0.05$), but there was an interaction between antioxidant and day ($P = 0.0008$) (Fig. 6). At day 3 in the control patties, the saturation values were similar to day 4 values in the antioxidant group. As seen with the other measurements, using the essential oil prolonged the degradation of the chroma values, which could provide an additional day during retail display in regard to the saturation of meat color. There was no light main effect presented ($P > 0.05$).

Conclusions

Throughout the duration of this study, antioxidants continued to behave in similar ways as recorded in the

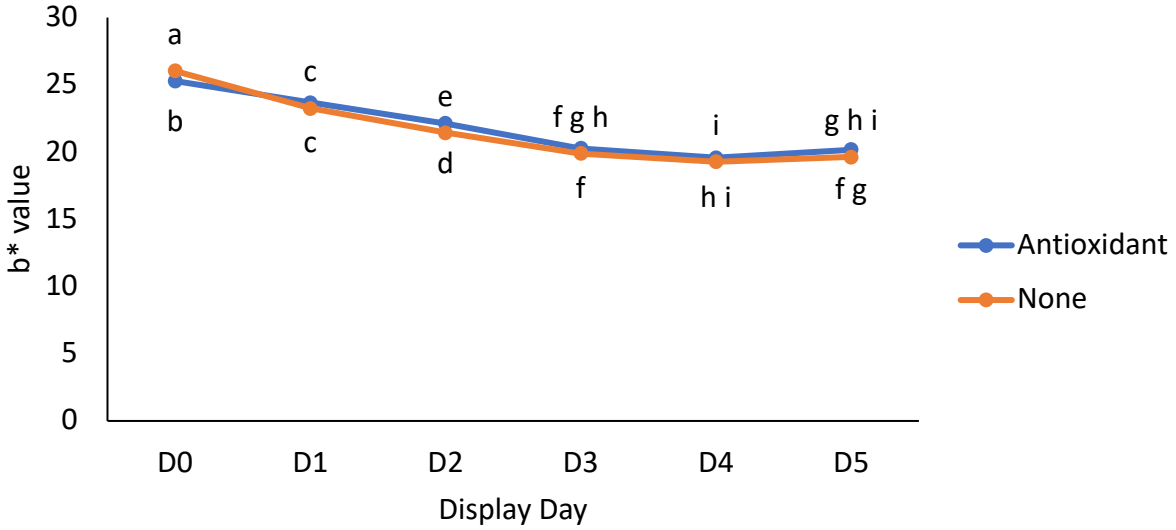

Fig. 4. Two-way interaction of antioxidant/no antioxidant treatment groups and display day on b* value ($P = 0.008$). Least square means without a common letter differ ($P < 0.05$). b* is a measurement of yellowness with positive values indicating yellow and negative values indicating blue.

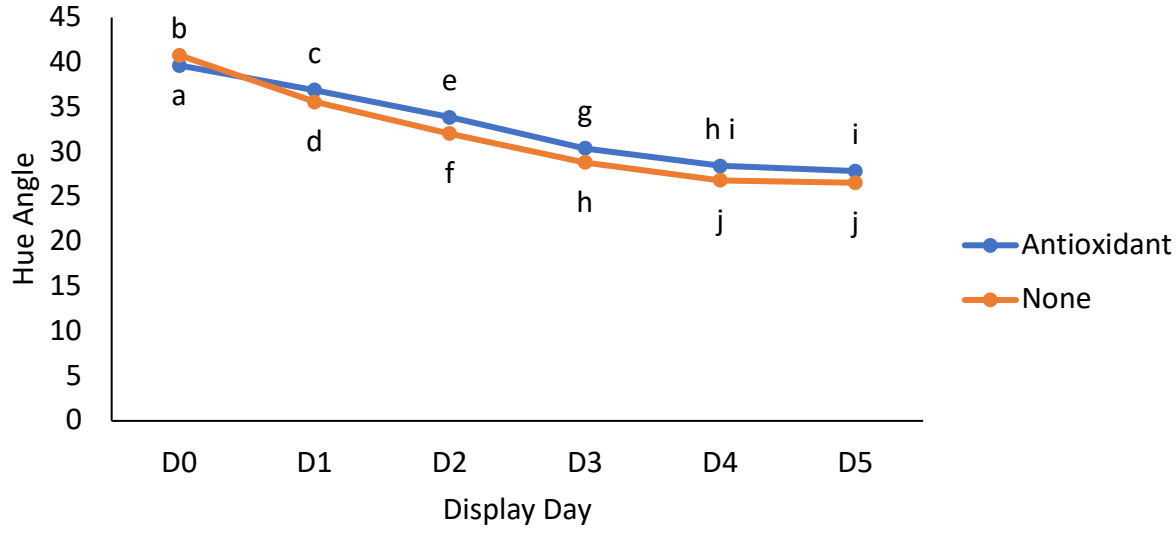

Fig. 5. Two-way interaction of antioxidant/no antioxidant treatment groups and display day on hue angle ($P < 0.0001$). Least square means without a common letter differ ($P < 0.05$). Hue angle is a relationship between a* and b* values, with smaller angles representing a redder color and larger angles representing a more yellow color.

literature, regardless of the introduction of lighting intensities. The introduction of antioxidants allowed for the prolongation of color values throughout a display period; however, based on the results of this study, there was no relationship between antioxidant use, lighting intensity, and day. When considering different means of maintaining meat color, antioxidants can be utilized to achieve this goal. The antioxidant effect found in essential oils such as rosemary continues to prove similar results as predicted regardless of lighting intensity. Adding an antioxidant to ground beef decreases lipid oxidation over a period of five days as compared to ground beef that has not been treated. Antioxidants reduce lipid oxidation regardless of the lighting intensity. As retailers and consumers continue to search for more ways to reduce the oxidation of their meat products and increase the shelf life, antioxidants can be used in ground products to achieve these results.

Acknowledgments

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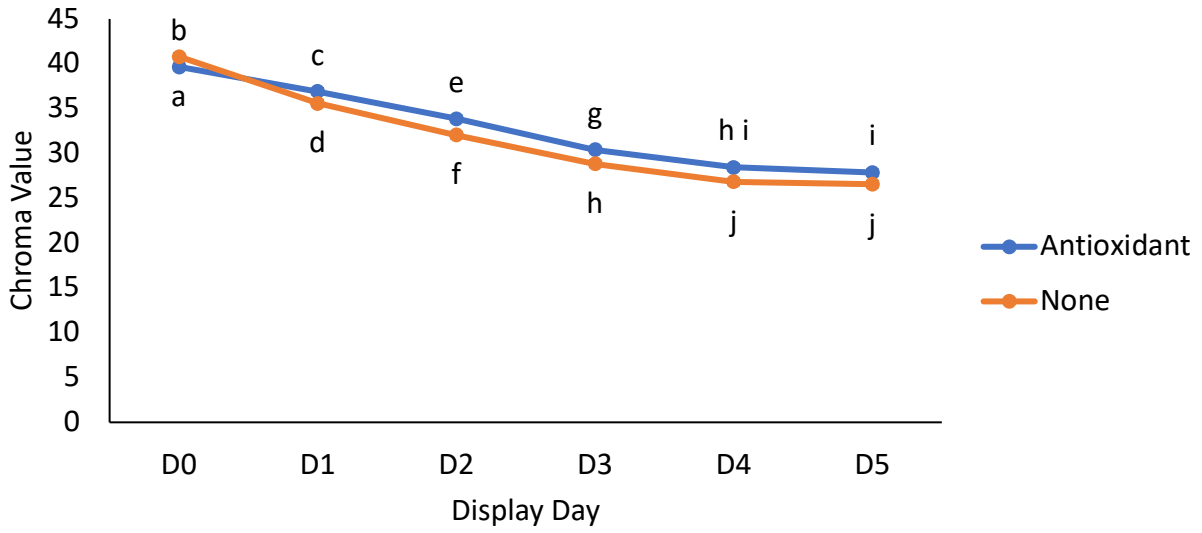

Fig. 6. Two-way interaction of antioxidant/no antioxidant treatment groups and display day on chroma value ($P = 0.0008$). Least square means without a common letter differ ($P < 0.05$).