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THE EFFECT OF COLD STORAGE ON THE COLOR OF VENISON

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Key words: venison, deer, color, storage.

Abstract

The objective of this study was to evaluate the color of unpackaged and vacuum-packaged venison during storage. Color parameters L^*, a^* and b^* were assessed in vacuum-packaged samples after 72, 144, 216, 288 and 360 h of storage, and in unpackaged samples – after 72, 144 and 216 h. The total change in color ΔE^* in comparison with the color of fresh meat was determined. The results indicate that the storage of unpackaged venison has an adverse effect on color, giving it a darker, grayish hue. The most profound changes were observed after 144 and 216 h of storage. Vacuum packaging of venison minimizes color change and has a long-term stabilizing effect for up to 15 days.

WPŁYW CHŁODNICZEGO PRZECHOWYWANIA NA BARWĘ MIĘSA JELENIA

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Słowa kluczowe: dziczyzna, jeleń, barwa, przechowywanie.

Abstrakt

W pracy oceniano barwę niepakowanego i pakowanego próżniowo mięsa jelenia podczas przechowywania. Oznaczenie parametrów barwy L^*, a^*, b^* wykonano w próbkach pakowanych próżniowo po 72, 144, 216, 288, 360 h przechowywania, zaś w niepakowanych po 72, 144, 216 h. Wyliczono również całkowitą zmianę barwy ΔE^* w stosunku do barwy mięsa świeżego. Wykazano, że przechowywanie mięsa jelenia bez opakowania zmienia niekorzystnie jego barwę, powodując ciemnienie i szarzenie. Zmiany miały największy zakres po 144 i 216 h przechowywania. Przechowywanie mięsa tego gatunku w opakowaniu próżniowym zmniejsza zakres zmian barwy, działając stabilizująco w długim okresie (do 15 dni).

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Introduction

Color is one of the most important parameters in evaluating the quality of raw meat. It is a key criterion for assessing unprocessed meat, as changes in color are often the first noticeable symptoms of the product's deteriorating sensory quality and nutritive value. Adverse changes in color during storage have a negative impact on the consumer evaluation of meat. The extent of such undesirable changes can be minimized through the use of various packaging methods. Vacuum packaging provides the simplest option of modifying the atmosphere surrounding the packaged product. Although an atmosphere composed of 80% O_2 and 20% CO_2 is generally believed to have the most beneficial effect on meat color, some research findings suggest that vacuum packaging contributes to the preservation of high-quality color (CAYUELA et al. 2004, DASZKIEWICZ 2007, INSAUSTI et al. 1999, OLIETE et al. 2005, SØRHEIM et al. 1996). Vacuum packaging is the predominant packaging method at small plants processing game carcasses. Venison is dark meat with a high content of heme pigments and iron, which is why chill storage contributes to adverse changes in its color (DZIERŻYŃSKI-CYBULKO, FRUZIŃSKI 1997, REDE et al. 1986, STRMISKOVA, STRMISKA 1992).

The objective of this study was to evaluate the color parameters of unpackaged and vacuum-packaged venison during cold storage.

Materials and Methods

The study was carried out on samples of *m. longissimus dorsi* of the red deer (*Cervus elaphus*). Carcasses of five hinds with average weight of 81 kg were used. *M. longissimus dorsi* was removed from the carcasses 24 h *post mortem*. Color parameters were evaluated on muscle surface according to CIE (International Commission on Illumination) standards: lightness (L^*), redness (a^*) and yellowness (b^*). Measurements were performed using the Dr Lange Spectro-Color device with an 8 mm measuring aperture, D 65 light source, standard colorimetric observer with a 10°C field of view, as well as SPECTRAL–QC software. Prior to measurement, the device was calibrated with the use of a black and white calibration template (Dr Lange). The muscle was divided into eight parts, five of which were vacuum packaged, and three were left unpackaged. All samples were stored at a temperature of 4 ±0.5°C, relative humidity of 85 ±1% and without light access. Color parameters on meat surface were determined in vacuum-packaged samples after 72, 144, 216, 288 and 360 h of storage, by unpacking the samples two hours prior to analysis (meat blooming, i.e. the highest level of oxymyoglobin saturation) (WIKLUND et al.

2001, WIKLUND et al. 2006), and in unpackaged samples – after 72, 144 and 216 h of storage. The results were used to calculate the total change in color ΔE^* after the respective storage time relative to the color determined 24 h *post mortem*. The following calculation formula was applied: $\Delta E^* = ((\Delta L^*)2 + (\Delta a^*)^2 + (\Delta b^*)^2)^{1/2}$ (BILLER, WIERZBICKA 2003). The results were processed statistically by computing the arithmetic mean and the standard error of the mean (SEM) SEM = s/√n, where s – standard deviation, n – number of samples. The significance of differences was determined with the use of Duncan's test at $p \leq 0.01$ (GAWĘCKI, WAGNER 1984).

Results and Discussion

The lightness of *m. longissimus dorsi* of deer carcasses reached 27 units 24 h *post mortem*, confirming that venison is dark-colored meat (DASZKIEWICZ 2007, DZIERZYŃSKA-CYBULKO, FRUZIŃSKI 1997, REDE et al. 1986). Significant changes in the above color parameter were noted in unpackaged meat already after 72 hours of storage when lightness decreased by 4.6 units. Further storage resulted in a steady decrease in the investigated color parameter. After 216 h, the value of L^* was only 15 units, i.e. 57% of its initial value, and significant differences were noted in comparison with the data obtained during previous measurements (Figure 1).

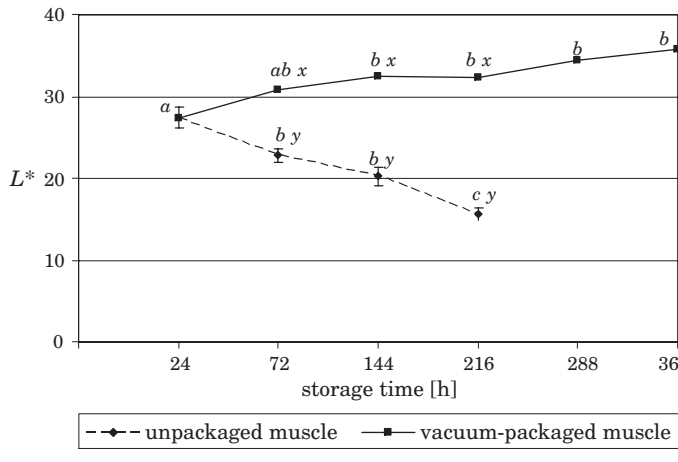

Fig. 1. Changes in the L^* color parameter of *m. longissimus dorsi* in the red deer (mean ± SEM) – the values marked with letters *a, b, c* on different curves differ significantly at $p \leq 0.01$ – the values marked with letters *x, y* on different curves after the same storage time differ significantly at $p \leq 0.01$

Vacuum-packaged meat was characterized by the following lightness parameters during storage: 72 h *post mortem* – 30.77, 144 h *p.m.* – 32.55, 216 h *p.m.* – 32.40, 288 h *p.m.* – 34.51 and 360 h *p.m.* – 35.76. This parameter was stabilized when storage conditions were modified to vacuum packaging. Significant differences were observed between the values determined for 24 h *p.m.* samples and samples analyzed 144 h *p.m.* and later. A comparison of the two experimental storage methods showed significantly lower L^* values in unpackaged meat after an identical time of storage.

Color redness (a^*) reached 13 units 24 h *post mortem*, indicating that this parameter significantly affects the color of meat from game animals. After 144 h of storage, color redness decreased significantly in unpackaged meat by 11.6 units to 1.6 units. In vacuum-packaged samples, no significant changes in color parameter a^* were noted after 360 h of storage. A comparison of the redness of unpackaged and packaged muscle samples revealed no significant differences up to 72 h of storage, while significant differences were observed after 144 h and 216 h of storage (Figure 2).

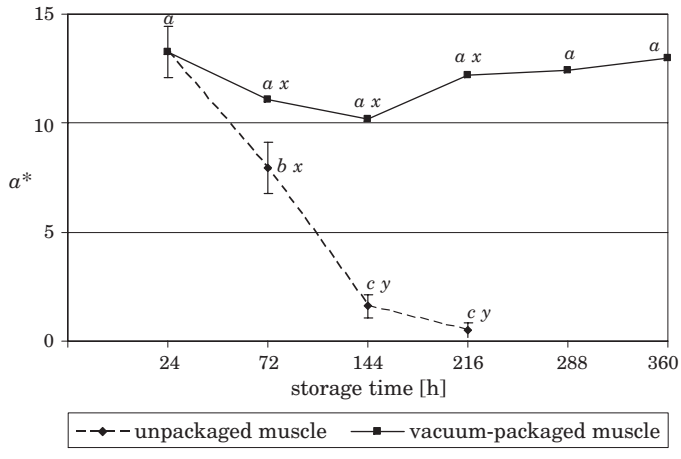

Fig. 2. Changes in the a^* color parameter of *m. longissimus dorsi* in the red deer (mean ± SEM) – the values marked with letters *a, b, c* on different curves differ significantly at $p \leq 0.01$ – the values marked with letters *x, y* on different curves after the same storage time differ significantly at $p \leq 0.01$

Contrary to color lightness and redness, color parameter b^* was marked by the least change throughout the experimental period. No differences in this parameter's share were noted during the storage of both unpackaged and vacuum-packaged meat. No significant differences in the share of color parameter b^* were observed subject to the applied storage method (Figure 3).

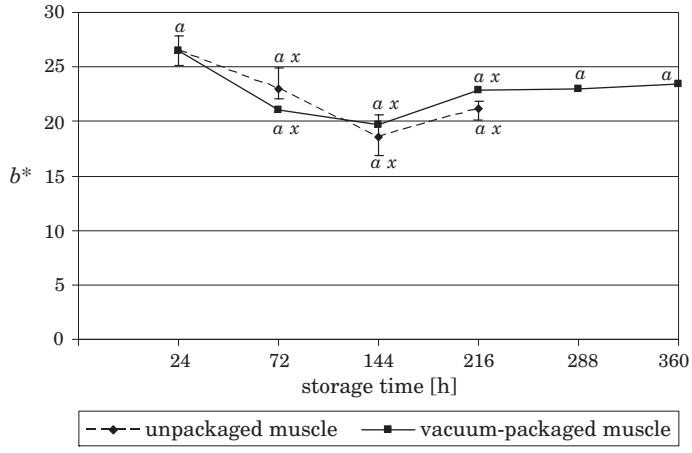

Fig. 3. Changes in the b^* color parameter of *m. longissimus dorsi* in the red deer (mean ± SEM) – the values marked with letter *a* on different curves do not differ significantly at $p \leq 0.01$ – the values marked with letter *x* on different curves after the same storage time do not differ significantly at $p \leq 0.01$

The color parameters of raw meat are determined by various factors, such as species, sex, age, diet, muscle type, pH, chemical composition, including the content of heme and other pigments, tissue enzyme activity, water-holding capacity and morphological structure (BOULLIANNE, KING 1998). In addition to the packaging method, the results of this experiment could have also been affected by pH, drip loss and water loss by evaporation from unpackaged meat. The results of a previous study evaluating the water-holding capacity of cold-stored venison did not show significant pH differences throughout the experiment or between unpackaged and vacuum-packaged meat (KWIATKOWSKA et al. 2009). In view of the above, the differences in the color of unpackaged and vacuum-packaged meat could be attributed to drip loss and water loss by evaporation from unpackaged samples.

Color lightness results approximate the data characteristic of the meat of 5-6-year-old farm-raised hinds (STEVENSON et al. 1992), and they are below the values noted in the meat from young farm animals where L^* reaches from 32 to 34 (STEVENSON et al. 1992, VOLPELLI et al. 2003, VERGARA et al. 2003, WOODFORD et al. 1996). A review of reference data indicates that the storage of venison under modified atmosphere conditions, with or without oxygen, over a period similar to that in the presented experiment, leads to a slight increase in L^* values by around 0.5–1.4 units (WERGARA et al. 2003).

The share of the redness parameter in venison color varies, reaching 13–14 units (STEVENSON et al. 1992), 15–17 (POLLARD et al. 2002, WERGARA et al. 2003, WOODFORD et al. 1996), 19 (DASZKIEWICZ 2007), and up to 21 units

(WIKLUND et al. 2001, WIKLUND et al. 2006). In the investigated meat samples, the value of a^* reached around 13 units, therefore, it was comparable. In a study by WIKLUND et al. (2006) and POLLARD et al. (2002), the redness parameter in vacuum-packaged red deer meat increased by around 4.5 units after 3 weeks of storage. By comparison, the values of color parameter a^* in vacuum-packaged samples in this study differed by around 3 units, therefore, the differences were statistically non-significant. It can be concluded that regardless of the applied packaging method, the storage of packaged venison always has a stabilizing effect on color redness.

The changes noted in the investigated color parameters are validated by the value of ΔE^*. After 72 h, the total change in the color of unpackaged muscle samples reached 8, after 144 h – 16, and after 216 h – 18. Already after 72 h of storage, ΔE^* was statistically significant, accounting for more than 40% of the maximum change in this parameter. In comparison with the changes observed after 72 h, the indicated changes after 144 h and 216 h were significantly higher (Figure 4). In vacuum-packaged samples, ΔE^* reached from 7.35 to 10.16 throughout the experiment, and no statistically significant differences were noted. A comparison of ΔE^* values between unpackaged and packaged muscle samples revealed significant differences after 216 h of storage.

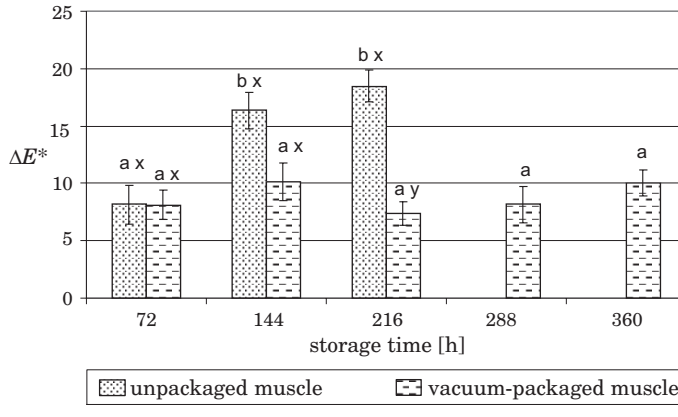

Fig. 4. Total change in the color of *m. longissimus dorsi* in the red deer (mean ± SEM) – the values for the same storage method, marked with letters *a, b,* differ significantly at $p \leq 0.01$ – the values for the same storage method after the same storage time, marked with letters *x, y*, differ significantly at $p \leq 0.01$

Conclusions

1. Cold storage of unpackaged venison has an adverse effect on color by significantly lowering the values of such parameters as lightness and redness.

2. Vacuum packaging stabilizes the color of venison cold-stored for minimum 15 days.

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