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COLOR STABILITY OF RETAIL-READY BEEF DURING PROLONGED STORAGE. II. STORAGE TEMPERATURE INFLUENCES

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ABSTRACT

Steaks from 3 different muscles were either vacuum or CO_2 packed and stored for up to 24 weeks at 3 different storage temperatures (-1.5, 2, or 5 °C). Following storage they were displayed for up to 30 h. Measurements of pH, color and surface discoloration, CIE color co-ordinates, and the oxidative states of myoglobin were taken prior to storage, during display (0, 1, 2, 4, 6, 24, 30 h), and/or immediately following display. Prior to display, pH was negatively related to duration of storage, and samples stored at -1.5°C had the highest and samples stored at 5°C had the lowest pH. Perception of muscle color was influenced by duration of storage and display, but lower storage temperatures appeared to produce a stabilizing effect. Both lightness of muscle color and deoxymyoglobin (DOMB) content were apparently not influenced by storage temperature or duration of storage or display. Both oxymyoglobin (OMB) and redness were lost progressively during storage and display, but this loss was progressively lower as storage temperature decreased. Yellowness generally decreased as storage was prolonged, and this decrease was observed more quickly at higher storage temperatures. However, surprisingly b* values were not related to duration of display. Both surface discoloration and metmyoglobin (MMB) content increased progressively during storage and display. Samples stored at 5°C contained the most MMB and displayed the most surface discoloration, while samples stored at -1.5°C contained the least MMB and displayed the least surface discoloration.

INTRODUCTION

Although the effects of storage temperature on the microbiological and keeping qualities of meat have been thoroughly researched on both primal and retail-ready cuts. Very little research has focused on the effects of storage temperature on the color stability of retail-ready beef cuts. Consequently, the present study provides badly needed information, since the present study was designed to characterize and document changes in color stability during prolonged storage of beef retail-ready cuts, attributable to storage temperature.

EXPERIMENTAL

Samples were obtained, prepared, stored, displayed, and evaluated as previously described (Jeremiah *et al.*, 1995). Data were analyzed as previously described (Jeremiah, et al., 1995), except in this instance storage temperature, storage time, and display time and all two-way and three-way interactions were considered.

RESULTS

pH, prior to display, was negatively related to duration of storage, irrespective of storage temperature ($P<0.01$, $R^2=0.74$ to 0.89). However, after 50 h of display no relationship was observed ($P>0.05$). When statistically significant differences in pH were observed among storage temperatures, samples stored at -1.5°C generally had the highest and samples stored at 5°C generally had the lowest pH values. Sensory color scores were not related to either duration of storage or display in samples stored at -1.5°C, but were positively related to duration of storage in samples stored at 2 and 5°C and displayed for 6 h ($P<0.05$, $R^2=0.59$ and $P<0.01$, $R^2=0.79$, respectively). Sensory muscle color scores were also positively related to duration of display in samples stored for 15 weeks at 2°C ($P<0.01$, $R^2=0.59$) and samples stored for 12, 15, and 24 weeks at 5°C ($P<0.05$, $R^2=0.58$ to 0.86). Prior to storage, samples to be stored at -1.5°C generally received the highest color scores ($P<0.05$) and were perceived to have the darkest color. However, after prolonged storage and display, samples stored at -1.5°C generally received the lowest color scores and were perceived to be the lightest ($P>0.05$). Consequently, these findings demonstrate duration of storage and display influences muscle color scores and low storage temperatures (-1.5°) appear to have a stabilizing effect. CIE L* values were not related to duration of storage or display at any of the storage temperatures evaluated ($P>0.05$). Few significant differences in L* values were observed among storage temperatures and these differences were not consistent. Consequently, storage temperature appeared to exert little influence on muscle color lightness, and lightness did not appear to be influenced by duration of storage or display. CIE a* values were negatively related to duration of storage in samples stored at -1.5°C and displayed for at least 6 h ($P<0.01$, $R^2=0.79$ to 0.94), samples stored at 2°C and displayed for at least 1 h ($P<0.05$, $R^2=0.53$ to 0.83), and samples stored at 5°C and displayed for at least 1 h ($P<0.05$ $R^2=0.60$ to 0.92). They were also negatively related to duration of display in samples stored at -1.5°C for at least 15 weeks ($P<0.05$, $R^2=0.66$ to 0.76), and samples stored at 2°C for at least 12 weeks ($P<0.05$, $R^2=0.50$ to 0.60). In unstored samples, samples to be stored at 2 and 5°C were observed to have higher a* values than samples to be stored at -1.5°C ($P<0.05$). However, after prolonged storage and display all differences between storage temperatures were generally significant ($P<0.05$) and samples stored at -1.5°C had the highest a* values, while samples stored at 5°C had the lowest and samples stored at 2°C were intermediate. These findings demonstrate redness was lost from muscle color during storage and display, irrespective of storage temperature. However, this loss was progressively lower as storage

temperature decreased, clearly demonstrating the beneficial effects of low storage temperature (-1.5°C). CIE b* values were positively related to duration of storage in samples stored at -1.5°C, prior to display ($P<0.05$, $R^2=0.50$) but were negatively related to duration of storage in samples stored at -1.5°C, when displayed for at least 24 h ($P<0.01$, $R^2=0.62$ to 0.66), samples stored at 2°C when displayed for at least 2 h ($P<0.05$, $R^2=0.46$ to 0.67), and samples stored at 5°C, when displayed for at least 1 h ($P<0.05$, $R^2=0.58$ to 0.85). b* values were also negatively related to duration of display in samples stored at 5°C for 18 weeks ($P<0.05$, $R^2=0.59$). When statistically significant differences were detected among storage temperatures, samples stored at -1.5°C generally had the highest b* values and samples stored at 5°C generally had the lowest. These findings indicate the yellowness of samples generally decreased with storage time but this decrease was observed more quickly at higher storage temperatures, indicating loss of yellowness was temperature dependent. However, surprisingly b* was generally not related to duration of display. Following storage, samples stored at -1.5°C generally had the most yellow color and samples stored at 5°C generally had the least yellow color.

Percent deoxymyoglobin (DOMB) was not related to duration of display irrespective of storage temperature ($P>0.05$), and was only negatively related to duration of storage, when samples were stored at 5°C, prior to display ($P<0.05$, $R^2=0.55$). Although statistically significant differences in DOMB content were observed among storage temperatures, particularly prior to display, they were not consistent. Consequently, they are unlikely to be of practical importance, indicating storage temperature and duration of storage and display exert little influence on DOMB content. Percent oxymyoglobin (OMB) was negatively related to duration of storage in samples stored at -1.5°C, when displayed for at least 24 h ($P<0.05$, $R^2=0.48$ to 0.58), samples stored at 2°C, when displayed for at least 4 h ($P<0.01$, $R^2=0.61$ to 0.92) and samples stored at 5°C, when displayed for at least 4 h ($P<0.01$, $R^2=0.86$ to 0.96). OMB content was also negatively related to duration of display in samples stored at -1.5°C for at least 18 weeks ($P<0.05$, $R^2=0.61$ to 0.64) samples stored at 2°C for at least 15 weeks ($P<0.05$, $R^2=0.61$ to 0.64), and samples stored at 5°C for at least 9 weeks ($P<0.05$, $R^2=0.49$ to 0.58). In unstored samples, samples to be stored at -1.5°C generally had the lowest and samples to be stored at 5°C generally had the highest OMB contents. After prolonged storage and display differences in OMB were generally significant ($P<0.05$) and samples stored at -1.5°C generally had the highest and samples stored at 5°C generally had the lowest OMB contents, with samples stored at 2°C being intermediate. These findings demonstrate the detrimental effects of storage and display on OMB content. However, such detrimental effects appear to be temperature dependent, with samples stored at lower temperatures generally being redder and containing more OMB, clearly demonstrating the beneficial effects of low storage temperature (-1.5°C) on muscle color redness, OMB content, and color stability.

Surface discoloration scores were positively related to duration of storage in all samples stored at 5°C, ($P<0.01$, $R^2=0.71$ to 0.98), samples stored at 2°C and displayed for at least 1 h ($P<0.01$, $R^2=0.59$ to 0.96), and samples stored at -1.5°C and displayed for at least 24 h ($P<0.05$, $R^2=0.42$ to 0.53). They were also positively related to duration of display in samples stored at -1.5°C for at least 3 weeks ($P<0.05$, $R^2=0.59$ to 0.95), samples stored at 2°C for all storage intervals ($P<0.05$, $R^2=0.53$ to 0.77), and samples stored at 5°C for 0 to 15 and 24 weeks ($P<0.05$, $R^2=0.55$ to 0.83). After prolonged storage and display all differences among storage temperatures were significant ($P<0.05$) and samples stored at 5°C were the most discolored, samples stored at -1.5°C were the least discolored, and samples stored at 2°C were intermediate. These findings clearly demonstrate surface discoloration increases progressively during storage and display. This deterioration appeared to be temperature dependent, with samples stored at 5°C becoming the most discolored and samples stored at -1.5°C becoming discolored to the least extent. Percent metmyoglobin (MMB) was positively related to duration of storage in samples stored at 5°C and displayed for at least 1 h ($P<0.05$, $R^2=0.40$ to 0.96), samples stored at 2°C and displayed for at least 4 h ($P<0.05$, $R^2=0.48$ to 0.88), and samples stored at -1.5°C and displayed for at least 24 h ($P<0.05$, $R^2=0.76$ to 0.79). MMB content was also positively related to duration of display in samples stored at 5°C for 3 to 18 weeks ($P<0.05$, $R^2=0.53$ to 0.69), samples stored at 2°C for at least 3 weeks ($P<0.05$, $R^2=0.59$ to 0.79), and samples stored at -1.5°C for 3 and 9 to 24 weeks ($P<0.05$, $R^2=0.64$ to 0.85). In unstored samples, samples to be stored at -1.5°C generally had the highest MMB contents ($P<0.05$). However, after storage samples stored at -1.5°C generally had the lowest MMB contents ($P<0.05$). After prolonged storage and display, all differences among storage temperatures were significant ($P<0.05$) and samples stored at -1.5°C contained the least amount of MMB, samples stored at 5°C contained the most, and samples stored at 2°C were intermediate. These findings clearly demonstrate MMB accumulates progressively during storage and display and this accumulation was temperature dependent, with most rapid accumulation occurring at the highest storage temperatures and the lowest accumulation occurring at -1.5°C. The fact samples stored at -1.5°C contained the most MMB prior to storage and the least after storage further substantiates the benefits of low storage temperatures (-1.5°C).

CONCLUSIONS

Storage at -1.5°.C provided the greatest color stability, and color became progressively less stable as storage temperature increased. Both storage and display produced detrimental effects on color, but such effects were lessened by lower storage temperature.

REFERENCES

Jeremiah, L.E., L.L. Gibson, and S. Nesom-Fleet 1995. Color stability of retail-ready beef during prolonged storage. I. Muscle influences. Proc. 41st Ann. ICoMST (in press).