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COLOR STABILITY OF RETAIL-READY BEEF DURING PROLONGED STORAGE. I. MUSCLE INFLUENCES

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ABSTRACT

Steaks from 3 different muscles (*longissimus dorsi* (LD), *semimembranosus* (SM), and *psoas major* (PM)) were either vacuum or CO_2 packed and stored for up to 24 weeks. Following storage they were displayed for up to 30 hours. Measurements of pH, color and surface discoloration, CIE color coordinates, 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. The 3 muscles evaluated differed considerably in color stability following storage and prior to display. pH decreased progressively as storage was extended, irrespective of muscle source. Subjective and objective perception of color lightness were not related to duration of storage or display. PM was perceived to be the darkest and LD was perceived to be the lightest. LD had the highest and SM had the lowest CIE L* values. LD displayed the least surface discoloration in unstored samples, Surface discoloration generally increased progressively during storage and display, and after prolonged storage and display, PM displayed the most and LD displayed the least. Likewise LD contained the lowest proportion of metmyoblobin (MMB) prior to storage and PM generally contained the highest proportion after 3 or more weeks of storage. However, MMB content generally increased progressively during both storage and display, irrespective of muscle source, but PM and SM were more susceptible to MMB formation than LD. LD contained the highest proportion of oxymyoglobin (OMB) in unstored samples and PM contained the lowest proportion prior to display. OMB content decreased progressively during both storage and display, irrespective of muscle source. Redness (CIE a* values) was also progressively lost during storage and display, irrespective of muscle source, but PM lost redness at the fastest rate. Yellowness (CIE b* values) was also generally lost during storage, if samples were displayed for at least 2 hours. However, yellowness was not lost during display. SM contained the lowest proportion of deoxymyoglobin (DOMB) in unstored samples, but differences were not observed after storage. DOMB was not related to either the duration of storage or display.

INTRODUCTION

Very little information is presently available regarding the color stability of different muscles after being stored anoxically for prolonged periods, particularly when stored as retail-ready cuts. Consequently, the present study provides badly needed information, by being designed to characterize changes in the color stability of specific muscles following anoxic storage for various periods of time.

EXPERIMENTAL

Grade A *longissimus dorsi* (LD), *psoas major*(PM), and *semimembranosus* (SM) muscles were obtained from a federally inspected abattoir and were transported to the Lacombe Research Centre (mean temperature during transport = 1.7°C) after being vacuum packaged. Immediately upon arrival the muscles were removed from their vacuum packages and 2.5 cm was trimmed from each end of each muscle. All subcutaneous fat was then removed and each muscle was cut into 2.5 cm thick steaks. A total of 324 steaks (108 from each muscle) were utilized. Fifty percent (54) of the steaks from each muscle were vacuum packaged (V) and the remaining 50% were packaged in a 100% CO_2 atmosphere (2.3 *l*/kg), (CAP). All steaks were packaged in an 0_2-impermeable foil laminate material, with a gas transmission rate of <0.01 cc/m^2/24 h. After packaging all CAP had residual 0_2 levels <300 ppm. V and CAP packages were then randomly assigned to 3 storage temperatures (-1.5, 2.0, and 5.0°C) and 9, 3-week storage intervals (0-24 weeks), within muscles. After each storage interval, steaks were removed from their foil laminate pouches and placed on styrafoam trays. Three surfaces pH measurements per steak were taken at 3 different locations. The trays were then overwrapped with an oxygen permeable film (OTR = 8000 cc/m^2/24 h) and were then placed in a fan-circulated, horizontal-type retail display case with a mean temperature of 6.3°C, under 1076 lux of incandescent and fluorescent lighting, at the meat surface. A 5-member, trained sensory panel evaluated color intensity using a 9-point descriptive scale (0 = completely discolored; 1 = white; 8 = extremely dark red) and surface discoloration with a 7-point descriptive scale (1 = 0%; 7 = 100%). Color was also objectively evaluated using reflectance spectropholometry. Reflectance measurements were taken at 3 different locations on each steak to obtain reflectance values from 360 to 670 mm. Linear interpolation was used to obtain values at 474, 525, 572, and 610 mm. CIE L*, a*, and b* values were obtained in addition to the proportions of deoxymyoglobin (DOMB), oxymyoglobin (OMB) and metmyoglobin (MMB) according to procedures outlined by AMSA (1991). Color measurements were taken after 0, 1, 2, 4, 6, 24, and 30 h of display, and pH measurements were repeated after 30 h of display as previously described. The entire experiment was replicated, except after storage all steaks were kept in the dark at -1.5°C, instead of being displayed under simulated retail conditions.

Data were analyzed using the general linear model of SAS (SAS 1989). Since there was a completely balanced design and interactions were not of interest the data were pooled and the main effects were examined separately. In this instance muscle, storage time, and display time and all two-way and three-way interactions were considered. The significance of differences between means was determined with the Student-t test. Linear regression was utilized to detect significant time trends during storage and display.

RESULTS

Prior to display and after 30 h of display, pH was negatively related to duration of storage in all muscles evaluated (LD, R^2=0.85 and 0.81, P<0.05; PM, R^2= 0.88 and 0.90, P<0.01; SM, R^2=0.81 and 0.42, P<0.05, respectively). Consistent differences in pH were not observed among storage/display intervals.

Sensory color scores were generally not related to duration of storage or display. PM generally received the highest and LD generally received the lowest color scores, indicating PM was perceived to be the darkest in color and LD was perceived to be the lightest. CIE L* values were generally not related to duration of storage or display. However, prior to display L* was related to duration of storage in the LD and PM (R^2=0.67 and 0.79, P<0.01, respectively). The LD generally had the highest L* values and the SM generally had the lowest L* values. CIE a* values were negatively related to duration of storage after all display intervals in the LD (R^2=0.44 to 0.83, P<0.05). CIE a* values were also negatively related to duration of display in samples stored for prolonged periods (≥12 weeks) (R^2=0.58 to 0.74, P<0.01). PM a* values were also negatively related to duration of storage in samples displayed for at least 1 h (R^2=0.59 to 0.74, P<0.01). SM a* values were also negatively related to duration of storage in samples displayed for 1 h or longer (R^2=0.46 to 0.90, P<0.05), and to duration of display in samples stored for at least 9 weeks (R^2=0.61 to 0.76, P<0.05). After prolonged storage and display PM samples generally had the lowest a* values (P<0.05). Redness was lost from most samples as both storage and display were prolonged, irrespective of muscle source. However, PM samples lost redness at the fastest rate. CIE b* values were not related to duration of display (P>0.05). However, negative relationships with duration of chilled storage were observed in LD samples displayed for at least 2 h (R^2=0.45 to 0.83, P<0.05), PM samples displayed for 2, 4, 24, and 30 h (R^2=0.41 to 0.72, P<0.05), and SM samples displayed for 4, 24, and 30 h (R^2=0.64 to 0.79, P<0.01). No consistent differences in b* values were observed between muscles. Thus, yellowness was generally lost from samples as storage was extended, when samples were displayed for at least 2 h. The proportion of DOMB was not related to the duration of storage or display (P>0.05), and consistent differences were not observed among muscles in DOMB content. However, in unstored samples SM generally contained the least DOMB (P<0.05). The proportion of OMB was negatively related to duration of storage in LD samples displayed for at least 2 h (R^2=0.49 to 0.94, P<0.05), PM samples displayed for at least 1 h (R^2=0.50 to 0.88, P<0.05), and SM samples displayed for at least 6 h (R^2=0.61 to 0.98, P<0.01). It was also negatively related to duration of display in LD samples stored for 15 weeks or longer (R^2=0.56 to 0.65, P<0.05), PM samples stored for 3 weeks or longer (R^2=0.53 to 0.61, P<0.05) and SM samples stored for 12 weeks or longer (R^2=0.61 to 0.67, P<0.05). When unstored, LD contained the most OMB prior to display and PM generally contained the least. This was also the case after 1 or more h of display, and after prolonged storage and display all differences in OMB content were generally significant (P<0.05) with LD containing the most, PM containing the least, and SM being intermediate. Therefore, both storage and display have negative influences on OMB content, producing a loss of redness in all muscles evaluated. Moreover, it is clear the 3 muscles evaluated differed substantially in color stability following storage and subsequent display.

Surface discoloration scores were positively related to duration of chilled storage in all LD and PM samples (R^2=0.55 to 0.96, P<0.05 and R^2=0.66 to 0.96, P<0.01, respectively) and in SM samples displayed for at least 4 h (R^2=0.53 to 0.85, P<0.05). They were also positively related (P<0.05) to duration of display in all LD (R^2=0.58 to 0.83), PM (R^2=0.50 to 0.79), and SM (R^2=0.56 to 0.85) samples. LD samples displayed the least amount of surface discoloration (P<0.05) in unstored samples. After prolonged storage and display all differences in surface discoloration among muscles were statistically significant, with PM samples displaying the most, LD samples displaying the least, and SM samples being intermediate. The proportion of MMB was positively related to the duration of storage in LD samples displayed for at least 2 h (R^2=0.55 to 0.92, P<0.05), PM samples displayed for at least 1 h (R^2=0.44 to 0.90, P<0.05), and SM samples displayed for at least 4 h (R^2=0.50 to 0.98, P<0.05). MMB content was also positively related to duration of display in LD samples stored for 3 and 9 to 24 weeks (R^2=0.67 to 0.85, P<0.05), PM samples stored for 3 to 21 weeks (R^2=0.52 to 0.74, P<0.05) and SM samples stored for at least 3 weeks (R^2=0.52 to 0.74, P<0.05), LD samples contained less MMB than PM and SM samples, prior to storage (P<0.05). After 3 or more weeks of storage PM samples generally contained the most metmyoglobin, and after prolonged storage and display all differences in MMB among muscles were statistically significant (P<0.05), with PM containing the most, LD containing the least, and SM being intermediate. Consequently, MMB content was significantly influenced by both storage and display, irrespective of the muscle source. However certain muscles (LD) appear to be more resistant to MMB formation, and consequently have greater color stability.

CONCLUSIONS

LD had the greatest color stability and PM had the least. Both storage and display produced detrimental effects on muscle color, irrespective of muscle source. The color of both LD and SM remained relatively stable during 12 weeks of storage. However, the color of PM deteriorated progressively after 3 weeks of storage.

REFERENCES

AMSA 1991. Guidelines for meat color evaluation. Proc. 44th Ann. Recip. Meat Conf. 44: 232-248.

SAS 1989. SAS User's Guide: Statistics. Statistical Analysis Services Institute, Cary, NC.