Real Effect of pH on CIE L*, a* and b* of Loins during 24 h Chilling of Beef Carcasses

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ABSTRACT : Twenty six male Hanwoo (Korean cattle) carcasses were measured for pH, temperature and instrumental color changes of loins during 24 h post-mortem carcass chilling at 4°C in the cooler. The average internal temperature of loins was about 5°C after 24 h of chilling, and with the exclusion of those with an ultimate pH>6.0 (dark-cutters), the average pH value was 5.5. When all carcasses were considered for the partial correlation coefficient between color and pH, with the temperature effect excluded, CIE L*, a* and b* seemed to be affected significantly by pH during chilling process ($p<0.001$). However, when carcasses with dark-cutting condition were excluded, the correlation coefficients were much lower. In contrast, when the partial correlation coefficients between color and temperature, excluding the effect of pH on them, were analyzed, the relationship between color and temperature did not change much after values of DFD (dark, firm, dry) beef were excluded. The results suggested that the known interrelationship of color and pH in chilled beef loins be mainly due to the influence of temperature on pH and color. ***(Asian-Aust. J. Anim. Sci. 2002. Vol 15, No. 2 : 279-282)***

Key Words : Post-Mortem Chilling, Beef Loin Color, pH, Temperature

INTRODUCTION

Because consumers regard the bright red color of fresh beef as an indication of its freshness, this attribute is an important quality trait in the meat industry. In many countries, beef carcass grading criteria require an objective assessment of color on the cut surface of the rib-eye muscle, 15-30 minutes after ribbing (Hale, 1994).

Meat color is affected by various factors, intrinsic or/and extrinsic (Renerre, 1990), one of them being the rate or extent of glycolysis during post-mortem chilling of carcasses (Smith et al., 1977). The color of excised muscle soon after slaughtering is translucent. Its dark appearance alters as rigor mortis progresses and if sufficient glycogen was initially present, it becomes progressively more opaque until the ultimate pH is reached, at which stage its appearance is bright red upon cutting and oxygenating. The transition from translucent to semi-opaque occurs near pH 5.9 (MacDougall and Jones, 1981). It is well known that "dark-cutting" beef is associated with a high ultimate muscle pH - always above 6, and sometimes above 6.5 (Kauffman and Marsh, 1987). The pH values of muscles were lower as the muscle temperatures were higher due to the rapid glycolysis (Tarrant and Mothersill, 1987). Likewise, accelerated carcass cooling can cause delay in the rate of pH decline (Jeacocke, 1977; Murray, 1989).

The time from slaughter and carcass ribbing to measurement of color have been shown to be important factors influencing the frequency of occurrence of dark-colored beef at the time of grading. The incidence of dark-colored beef was three times higher at 15-18 h poststunning than at 22-26 h, due to the incomplete development of muscle color at the earlier times (Murray, 1989). In this case, beef with normal color had a mean ultimate pH of approximately 5.65 post-slaughter. A gradual pH decline to an ultimate pH of about 5.6 results in normal red meat which is capable of bloom development upon exposure to air (Cornforth, 1994).

Faster pH reduction is associated with faster bloom, which allows carcasses to be graded sooner (Cornforth and Egbert, 1985). However, Cornforth et al. (1985) reported that the bloom in pre-rigor muscle could be achieved by holding the muscle both at low temperature and in high oxygen concentration without lowering the pH.

Because the effect of the rate or the extent of post-mortem pH fall on color has been studied mostly from the viewpoint of ultimate pH, it was difficult to find literature regarding the relationship of color with pH during the first 24 h postmortem carcass chilling period. Therefore, this study was conducted to examine the relationship of meat color with postmortem pH during chilling of beef carcasses for the first 24 h after slaughter.

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MATERIALS AND METHODS

Material

Twenty six carcasses of Hanwoo (Korean cattle) male of 18-24 months old slaughtered for the Government procurement plan were used for this study. The dressed hot carcasses weighed between 300 and 350 kg.

Methods

Split carcasses were chilled for 24 h in the cooler at 4°C immediately after slaughter. The temperatures on the right side of carcasses were continuously recorded at the geometrical center of the loin during the 24 h period of chilling by using an electronic type self-balancing multipoint temperature recorder (Sekonic Co., Ltd., Japan, Model SA-180P12). Ribbing was done by sawing across the midpoint of the 7th vertebrae cranial to the lumbar-sacral junction as required by the Korean grading system (MAF, 1999). The color of the rib-eye was measured 30 minutes after ribbing with a Chroma Meter CR-310 (Minolta Co., Ltd., Japan). The pH was measured by inserting the electrode into the center of loin between ribs of the carcass with a pH meter (Cole-Parmer Inc., U.S.A., Model 5985-80) equipped with a spear-type electrode. Color and pH measurements of the loins were made on the left sides of carcasses at 3 h, 6 h, 9 h and 12 h during the 24 h chilling period whereas the right sides were evaluated at 24 h. The cut surfaces of the left sides were covered tightly by aluminum foils after each measurement. All data were pooled and analyzed for partial correlation coefficients and regressions between factors with a SAS (1995) package.

RESULTS AND DISCUSSION

During 24 h postmortem chilling of carcasses, no relationship ($p>0.05$) was found between beef loin temperature and pH. However, when DFD (dark, firm, dry) beef (pH>6.0 at 24 h postmortem) were excluded, pH values were significantly related with loin temperatures during 24 h chilling (figure 1). Figure 1 depicts that pH decreased as the carcass temperature declined during 24 h carcass cooling. These observations show that both pH and temperature of loins decreased as postmortem glycolysis proceeded. In this study, the average temperature of about 5°C was reached after 24 h of chilling (figure 2). The average pH value of 5.6, excluding the DFD beef, was reached in about 12 h postmortem (figure 3).

The different temperature/pH regimes of individual muscles during post-mortem glycolysis can modify the

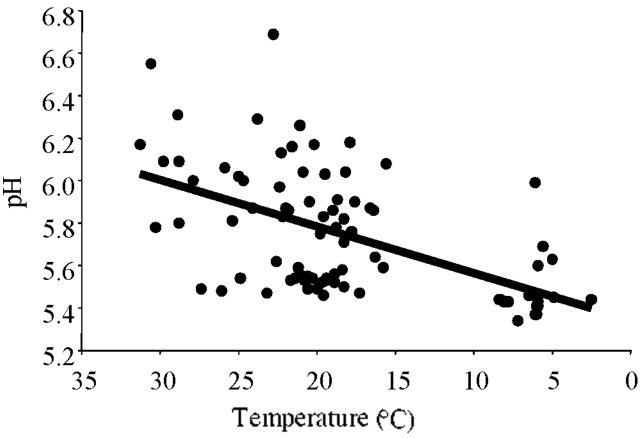

Figure 1. Relationship of ph (y) to temperature(x) of loins during 24 h postmortem cooling in beef without DFD condition $Y=0.02X+5.35$ ($r^2=0.290$, $p<0.01$)

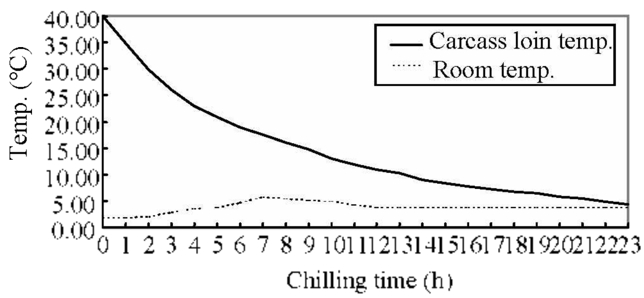

Figure 2. Temperature changes of loins during carcass chilling (loin temperature is mean value of 26 carcasses and standard deviation was ±3°C)

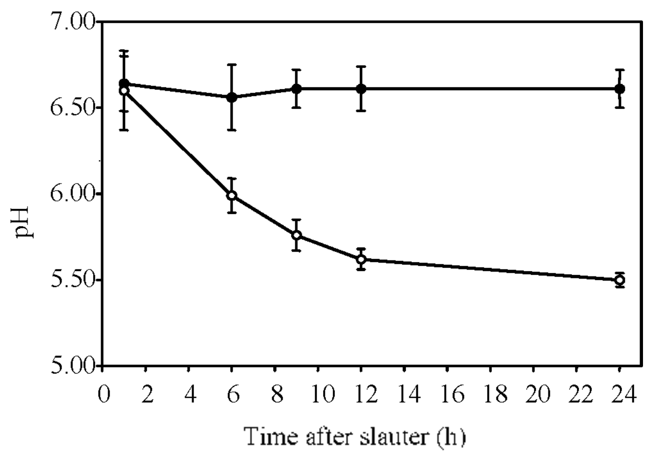

Figure 3. pH Changes of loins during 24 h carcass chilling (upper line is for DFD loins and lower line is for normal loins. All values are with s.d.).

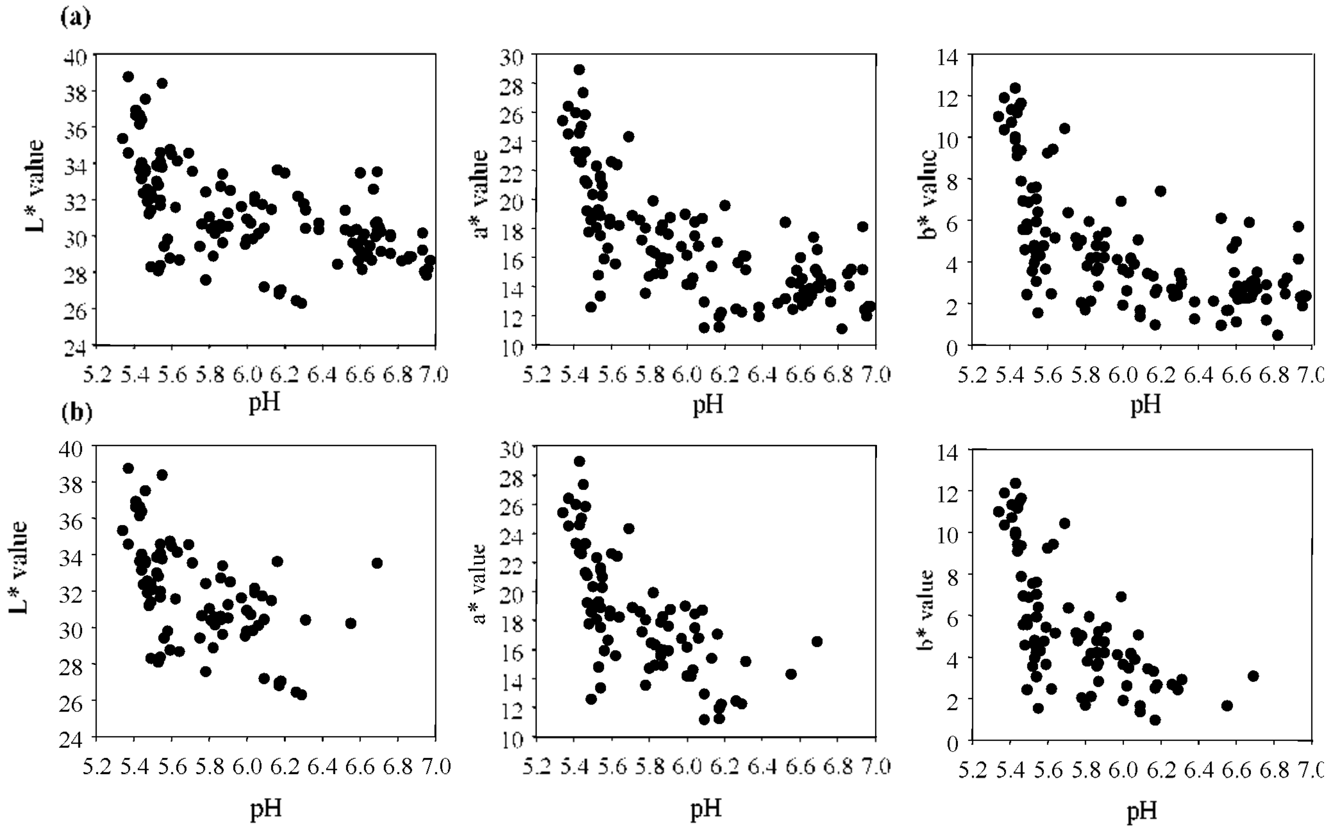

Figure 4. Relation between CIE L*, a* and b* and ph when temperature effect was excluded.
(a): in all carcasses(n=26); (b): in carcasses without DFD condition(n=18)

perceived color (Renerre, 1990). When all the data were analyzed for the partial correlation between color and pH with the elimination of temperature effect, the result revealed that the color was affected by pH ($p<0.001$). Lower pH readings were associated with higher values of L (lightness) ($r^2=0.2951$), a (redness) ($r^2=0.5889$) and b (yel- lowness) ($r^2=0.5546$) (figure 4-a).

However, there should not be any direct pH effect on chemical state of myoglobin as the oxygenation of myoglobin is not affected by pH (Govindarajan, 1973). At high pH (>6.0), mitochondria oxygen consumption is so high that in meat which is exposed to air, the surface oxymyoglobin layer is thin, so the purple color of myoglobin still predominates (Ashmore et al., 1972). The fact that figure 4-a included the data of DFD beef and pH changes in DFD beef were not affected much by temperature would explain the phenomena. Since a meat is classified as dark-cutting if it has an ultimate pH greater than 6.0 (Shorthose, 1988), only the data from carcasses with pH value less than 6.0 at 24 h post-mortem were utilized for the statistical analysis (figure 4-b). The correlation coefficients were much lower ($r^2=0.0999$ for L; $r^2=0.2495$ for a; $r^2=0.2212$ for b) than those in figure 4-a, showing the effect of post-mortem temperature on the correlation between color and pH, for the environment temperature has a marked effect on the rate of postmortem pH fall (Marsh, 1954)

When the effect of pH was eliminated, the partial correlation coefficients between color and temperature ($p<0.001$) did not change much even after values of DFD beef were excluded (figure 5-a and -b) ($r^2=0.1981$ for L, $r^2=0.5547$ for a, $r^2=0.6941$ for b in all carcasses; $r^2=0.1970$ for L, $r^2=0.5644$ for a, $r^2=0.7254$ for b in carcasses without DFD condition). This observation can be explained as the bright red color of beef is related to the lower oxygen consumption of mitochondria at low temperature (Cornforth and Egbert, 1985) and the effect of the increased mitochondrial activity at high pH was eliminated. These facts suggest that the color of loins be related more closely to its temperature than to pH.

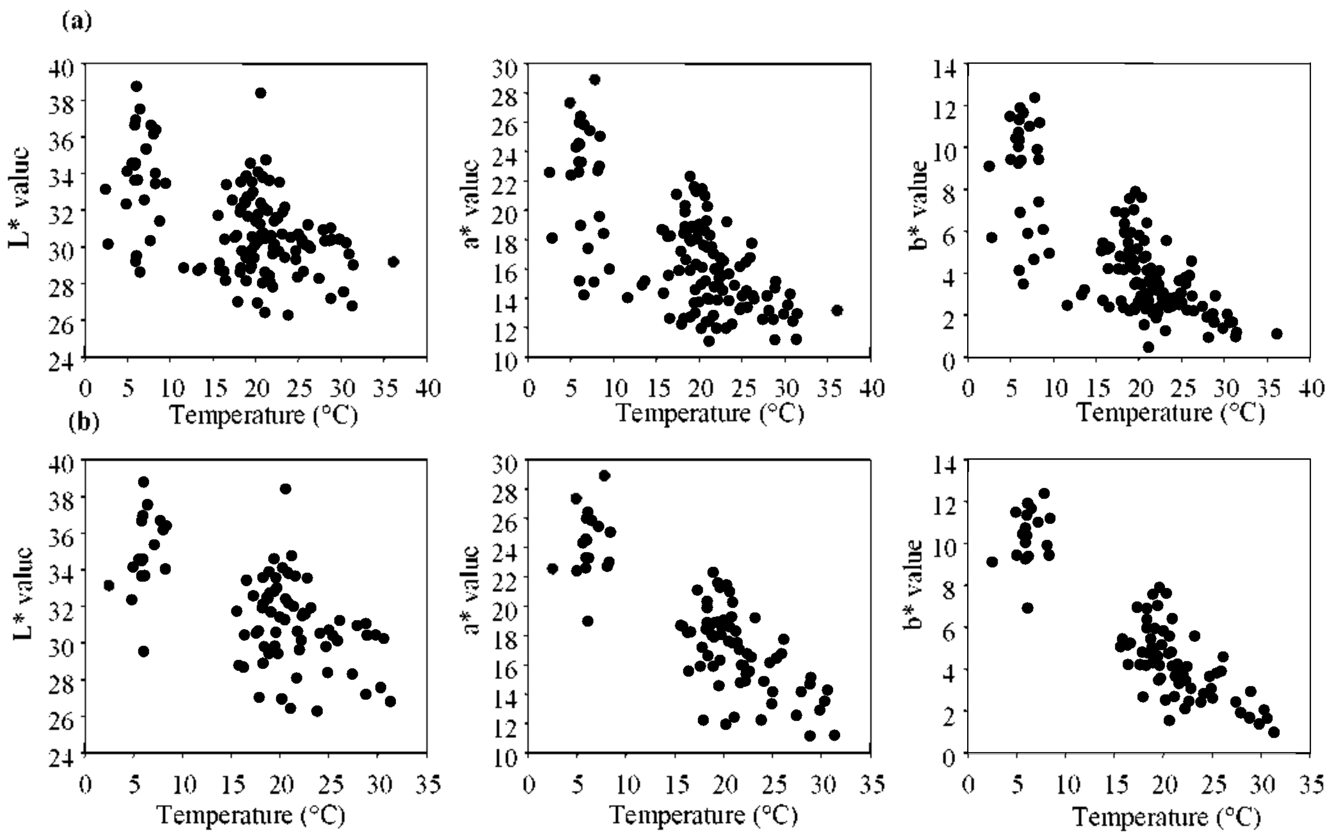

Figure 5. Relation between color and temerature when ph effect was excluded.
(a): in all carcasses(n=26); (b): in carcasses without DFD condition (n=18)

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