Variations in Lightness and Exudation Among Ten Porcine Muscles

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SUMMARY: The semimembranosus, biceps femoris, gluteus medius and the lateral portion of semitendinosus in the ham were similar in color and water-holding capacity to that of the longissimus thoracis (LT), regardless of the level of quality. When color was light or dark, or when water-holding capacity was low or high for the LT, the other four muscles behaved similarly. However, the psoas major, rectus femoris, triceps brachii, supraspinatus and infraspinatus were similar to the LT only when the color was dark and the water-holding capacity was high. Therefore, the LT could serve as a reliable indicator of color and water-holding capacity for all the muscles studied when the condition was dark, firm and dry. However, when the condition was pale, soft and exudative, then the LT would serve as a reliable indicator only for the four major ham muscles (excluding the rectus femoris).

INTRODUCTION: Quality as described by Judge (1991) and Kauffman et al. (1990) is extremely important when assessing the value of porcine musculature as it is used for food. Of the various parameters included in the definition of quality, two important ones are water-holding capacity (WHC) and color of fresh, post-rigor muscles because they are related to attractiveness, shrinkage during storage and processing, and to wholesomeness, nutritive value and palatability. When pork carcasses are assessed for value, it is nearly universally accepted to use the longissimus thoracis et lumborum as the indicator muscle for variations in quality of the entire carcass. Some past experiments conducted by Beecher (1966) have suggested this to be true for some muscles, and Barton-Gade and Olsen (1987) indicated that some muscles should be used to indicate the PSE condition and others used to indicate the DFD condition. If pork carcasses are to be effectively and practically evaluated for quality in commerce, then it is important to select a representative muscle to serve as an index of quality for the entire carcass musculature. Since the loin muscle 1) represents over 10% of the carcass muscle mass, 2) is subject to both the pale, soft and exudative (PSE) and dark, firm and dry (DFD) quality conditions and 3) is already used to determine composition (area or depth), it should serve as an ideal candidate (National Pork Producers Council, 1988). The purpose of this investigation was to select several large and economically important muscles representing various anatomical areas, determine their color and WHC, and then compare the results to those of the longissimus thoracis (LT) of carcasses varying considerably in quality.

MATERIALS and METHODS: Nineteen pork carcasses (~24 hr pm) were selected [using 45 min postmortem (pm) pH as an initial indicator] to represent wide variations in quality as initially determined by examining the LT. The carcasses originated from market weight hogs that were slaughtered and these carcasses chilled (2^{o}C) according to conventional procedures in a commercial pork packing plant. In addition to the LT, nine other muscles representing approximately one-half of the total musculature and three commercially important locations were used. They included the semimembranosus (SM), semitendinosus (ST), biceps femoris (BF), rectus femoris (RF), and gluteus medius of the ham, the psoas major (PM) and LT of the loin, and the triceps brachii (TB), supraspinatus (SS) and infraspinatus (IS) of the shoulder. The largest possible transverse sectional surface of each muscle was exposed for quality assessments. WHC was determined by the weight of fluid uptake on filter paper as described by Kauffman et al. (1986). Color lightness was determined by measuring the CIE L* value (triplicate readings) using the portable Minolta Chroma Meter 200b. Also, ultimate pH was recorded using an Omega combination glass electrode probe and portable meter. The LT was then assigned to one of five color-WHC quality categories as described by Kauffman (1991). If the color was pale (P) having an L*>56 and the WHC was unacceptable (U) having >100 mg fluid retained on the filter paper, then the category was PU. For a similar color but exhibiting acceptable (A) WHC (< 100 mg fluid), the category was PA. For normal reddish-pink colored muscle (R) ranging from 47 to 56 L*, and unacceptable WHC, the category was RU. If the color was reddish-pink and the WHC was acceptable, then the category was RA. The last category was reserved for dark red muscles that were acceptable in WHC and this category was designated as DA. This approach to identifying various combinations of color and WHC was an arbitrary way of classifying variations in color and WHC, and deviated from the traditional PSE, DFD and normal ones that assume the perfect relationship between color and WHC. Swatland (1987) has already raised questions about this and has suggested that the two quality parameters be treated independently as we have attempted to do here. The data were analyzed statistically by using box plots as described by Chambers et al. (1983). The box represents the interquartile range from the 25th to 75th percentiles, the line extensions represent the range of the data from 5th to 95th percentile (excluding extreme values), the cross bar within the box represents the median, and extreme observations are individually marked by circles.

RESULTS and DISCUSSION: Based on the LT measurements and the five arbitrary color-WHC categories, the 19 carcasses represented all five categories as are shown in Table 1.

Table 1. Objective Measurements of the Longissimus Thoracis for 5 Quality Classes

Class	n	pHi $\bar{X} \pm$ sd	pHu $\bar{X} \pm$ sd	L* $\bar{X} \pm$ sd	Exudate, mg $\bar{X} \pm$ sd
Pale and unacceptable WHC	3	5.8 ± 0.5	5.5 ± 1.1	58.9 ± 1.1	127 ± 13
Pale and acceptable WHC	2	6.0 ± 0.1	5.7 ± 0.1	57.5 ± 1.3	47 ± 22
Red and unacceptable WHC	3	5.7 ± 0.4	5.5 ± 0.1	44.9 ± 6.1	129 ± 17
Red and acceptable WHC	7	6.6 ± 0.2	5.7 ± 2.1	51.0 ± 2.1	47 ± 9
Dark and acceptable WHC	4	6.6 ± 0.2	6.2 ± 0.2	42.6 ± 2.3	28 ± 8

Initial pH (pHi) was helpful in selecting for this distribution. However, the ultimate pH (pHu) deviated only slightly among all the categories (except DA). Since the categories were arbitrarily assigned according to the L* and mg of fluid retained on the filter paper, the clearly different values for the various categories shown were expected. When WHC was expressed as fluid retained on filter paper and shown as a box plot on figure 1, it was quite clear that the ham muscles (except RF) varied similarly to that of the LT, but the other muscles did not. Upon closer examination of the data as shown in figure 2 where the PU, RA and DA categories were singled out for each of the 10 muscles, the ham muscles (except RF) possessed high fluid retentions along with that of the LT whereas the other muscles did not within the PU category. This relative relationship also

Figure 1: Box plots of water-holding capacity (filter paper (F.P.) fluid retention) for each of 10 porcine muscles

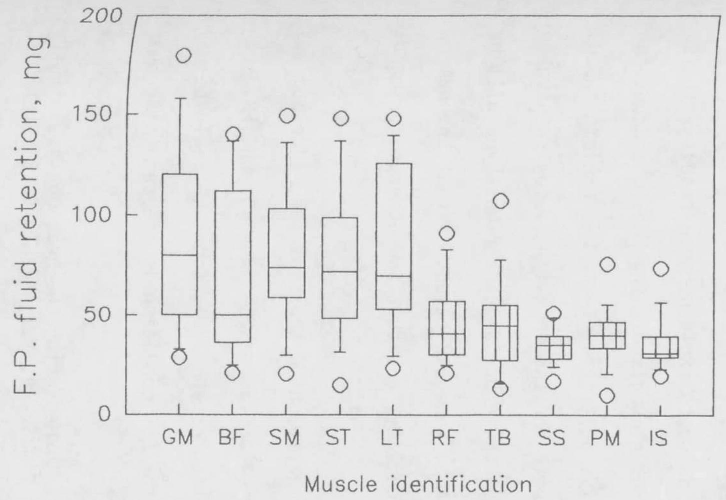


Figure 2: Mean water-holding capacity (filter paper (F.P.) fluid retention) for individual muscles within three quality groups

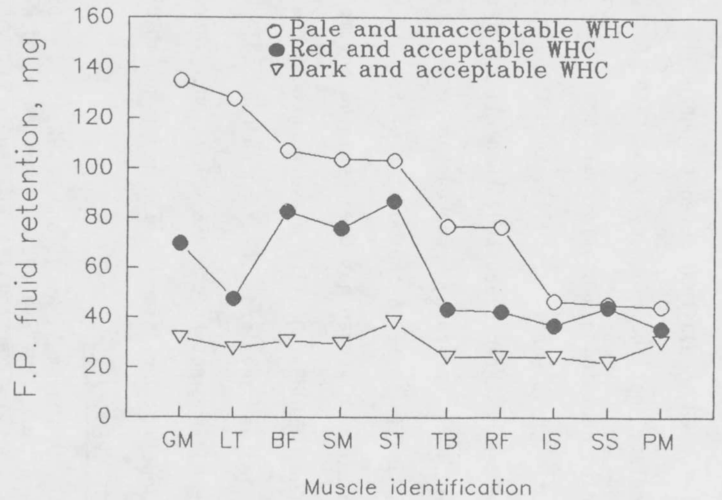


Figure 3: Box plots of surface lightness (L, 100= white) for each of 10 porcine muscles*

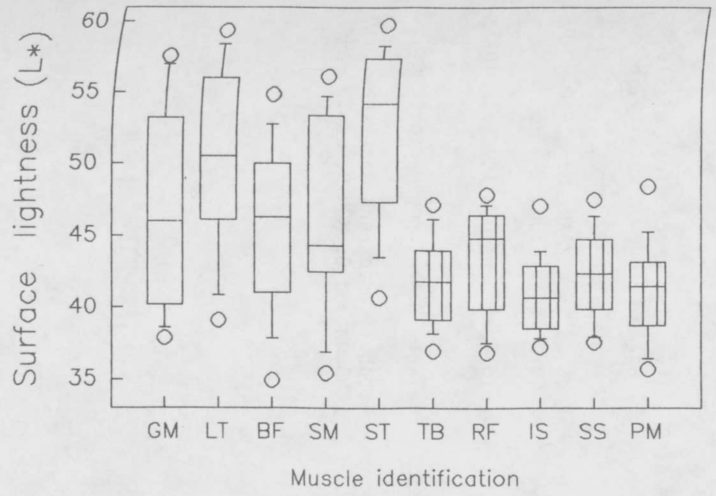
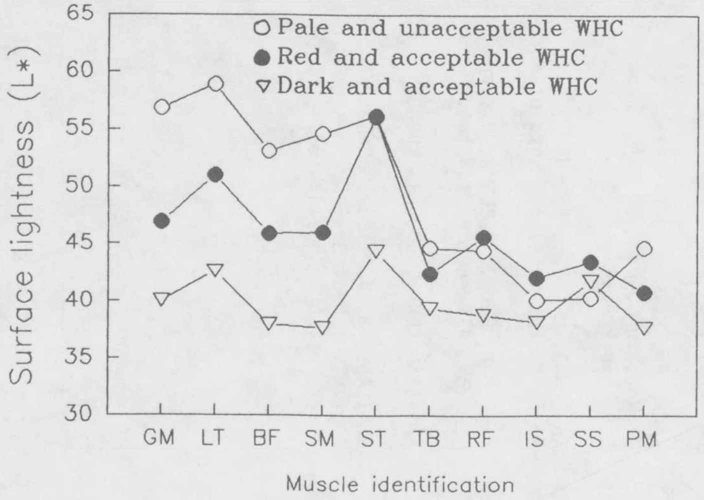


Figure 4: Mean surface lightness (L*, 100=white) measurements for individual muscles within three quality groups



prevailed for the RA category. However, when the DA category was compared for all 10 muscles, the fluid retention was uniformly low for all muscles. When color was considered (figures 3 and 4), the same results as that for WHC prevailed. Even though we did not develop evidence to explain these results, it is reasonable to speculate that the fiber type profile (fast, intermediate or slow glycolysing) could account for this. When muscles containing a considerable proportion of fast glycolysing fibers (i.e., LT) exhibit rapid pm glycolysis due to stress (Briskey, 1964), then the ultimate color is pale and the WHC will be low. Conversely, if muscle glycogen has been exhausted, then all muscles, regardless of their predominant fiber type will be dark with high WHC. Therefore, based on the results of this experiment, we would expect most of the ham muscles to respond similarly to that of the LT for all variations of quality, and that the other major muscles would only do so when glycogen has been depleted antemortem.

CONCLUSIONS: Quality measurements of the LT adequately represented those of the major ham muscles (except RF) in the range from pale and unacceptable WHC to dark and acceptable WHC. However the PM, RF, TB, SS and IS were not subject to the PSE condition. Therefore, quality (color and WHC) of the LT could be used to predict all quality variations of the major ham muscles, but only the DFD condition in the remaining muscles studied.

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