QUALITY DIFFERENCES AMONG BEEF M. *LONGISSIMUS DORSI* OF THE CANADA A, AA, AAA & PRIME GRADES

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Abstract – Meat quality characteristics of four Canadian beef grades; A, AA, AAA and Prime were determined by analyzing 48 *m. longissimus dorsi* (LD) muscles. Comparisons of meat color, pH, water holding capacity and shear force between all grades were performed. Findings of this study suggested that Canada A, AA and AAA were different from Prime in terms of L* (lightness). Drip loss was not significantly different (P = 0.057) although there was a trend toward LD from Canada A having the highest amount of drip loss (0.8%). Percentage of cooking loss differences among grades (P = 0.002) indicated that Canada AA had the highest cooking loss (18.7 %) when Canada Prime has the lowest (14.6%). Shear force was not significantly different among the Canada grades (P = 0.124). This could be related to the small quantity of samples (12 per grade group) which lacked power (0.75) for differences observed to be significant.

Key Words – Canadian beef grades, beef color, shear force, cook loss.

I. INTRODUCTION

Meat quality is the conjunct of acceptable sensory characteristics that meat should have in order to be commercial and profitable. These sensory characteristics are defined by color, tenderness, juiciness, flavor and aroma [1, 2]. In Canada, beef under thirty months of age that meet the texture, muscling, fat, and lean color are classified into four high quality grades based on the amount of intramuscular fat on the LD surface. High quality grades are: Canada A (traces of marbling), AA (slight marbling), AAA (small marbling) and Prime (slightly abundant marbling) [3]. Beef carcass grading allows us to estimate the eating quality of beef and as a result this classification is also used to set the value of the carcass as well. Although the Canadian grading system is used to set the value of the whole carcass, the true eating quality profile of each grade has not been determined, nor have the eating quality differences among Canada grades been described in recent years. However, quality properties of beef grades were described in 1976 by Hawrysh *et al.* [4] and the effects of marbling level on cooking and palatability properties of beef rib-eye steaks are described by Jones *et al.* in 1991 [5]. This study examined the meat quality differences among the four high quality Canada grades with the aim of increasing the quality profile of Canadian Beef in local and international markets.

II. MATERIALS AND METHODS

The surface of *m. longissimus dorsi* muscle between the 12th and 13th rib is the portion of the beef carcass that is graded and was the site where the quality measurements were taken. Certified meat graders by the Canadian Beef Grading Agency determined the quality grade of each sample. Twelve LD muscles from each grade (Canada A, AA, AAA & Prime) were obtained from a large Alberta abattoir. A total of 48 LD muscles were accepted into the study and analyzed at 3 to 4 days *post mortem*. Three 2.5 cm thick steaks were taken from each LD muscle; the first was used for objective color measurements, the second one was used for cooking loss and Warner–Bratzler shear force (WBSF) and the third one was used for pH and drip loss.

Color analysis is improved by increasing the number of measurement within a sample [6]; therefore, 3 locations along the LD muscle surface were chosen to take measurements, the three values were averaged and mean value recorded. Approximately 3mm of the outside face was removed and the newly exposed surface was allowed to bloom (meat oxygenation) while covered with polyethylene film at 4 ºC for 60 min. Lightness (L^*), green-red (a^*) and blue–yellow (b^*) values were determined with a Minolta Chromameter CR-400 (Konica-Minolta, Osaka, Japan) using the color system established by the Commission Internationale de L'Eclairage (CIE) [7]. The instrument was calibrated against a white tile provided with the instrument before use.

Measurements of pH were performed with a temperature-compensated pH meter (Fisher Scientific, Accumet Waterproof AP71 pH/mV/Temperature, Fisher Scientific, Toronto, ON) fitted with a glass probe electrode (Hanna Instruments, Fisher Scientific, Toronto, ON), which was inserted into the muscle. Three readings were taken from each muscle and the pH values were averaged and the mean used for statistical analysis. Prior to pH measurement, the pH meter and electrode were standardized using pH buffers of 4.0 and 7.0 at room temperature (23 ºC).

The water holding capacity was determined by drip loss [8] and cooking loss [9] methods. Drip loss was measured by first trimming the external fat from the LD steak and then hanging it for 24 hours at 4 ºC in a plastic bag from a stainless steel hook. The weight of the trimmed steak portion was recorded before and after the procedure, and water loss results expressed as a percentage of the original weight. To calculate cooking loss, LD steaks were trimmed of subcutaneous fat, weighed and grilled on a pre-heated grill (General Electric 4 in 1 Grill / Griddle) set to a temperature of 176 ºC. The internal temperature of each steak was monitored continuously using a (Tinytag View 2s) thermometer with a metal probe inserted into the geometric centre of the steak. Steaks were heated until the steak internal temperature reached 71 °C. Once an internal temperature of 71 ºC was reached, the cooked steaks were cooled to less than 10 °C in an ice bath and then weighed. Cooking loss was calculated by dividing the steak weight loss during cooking by the trimmed raw weight of the steak and reported as a percentage of the initial raw weight.

Cooked steaks were stored overnight at 4 °C. The next day steaks were removed from refrigerated storage and allowed to reach room temperature. Once the cooked steaks reached room temperature, 6 cores of 1.27 cm diameter and 2 cm long were removed from each steak parallel to the muscle fibers using a cork borer. Each core was sheared once across the middle, perpendicular to the long axis, using a materials testing machine (AMETEK, Inc. Lloyd Instrument LRX plus, Digital Metrology Measurements, Kitchener, ON) fitted with a Warner–Bratzler type shear blade. Shear force was expressed in Newtons (N) and values were averaged to obtain a mean value for each steak.

Data were organized as a randomized complete block design and analyzed using the MIXED procedure in the Statistical Analysis System (SAS) software (Version 9.2, Statistical Analysis Systems, Cary, NC, USA). Analysis of variance was conducted using beef grade as the sole fixed effect. Ribs were blocked by replicate of grades and block was included as a random source of variation. Grade effect was considered significant at $P \leq 0.05$ and where grade was significant least square mean differences were used to determine differences between grade means with significance at $P \leq 0.05$. In all analyses of variance, degrees of freedom were corrected using the Kenward-Roger adjustment.

The randomized complete block design model was:

$$y_{ij} = \mu + G_i + B_j + \varepsilon_{ij}$$

where:
μ: overall mean
G_i: grade
B_j: block
ε_{ij}: random deviation associated with each observation
where i = 1-4 and j = 1-12

III. RESULTS AND DISCUSSION

LD steaks from Canada Prime had the highest mean L^* value and were the most yellow (b^*) (Table 1). There were no differences in a^* values (coordinate green–red) among grades, although there was a trend toward Prime rib eyes being the most red ($P = 0.073$). Lean L^* values may have been increased in the Prime grade by the large amount of intramuscular fat related to this grade, as increased lightness of lean has been related to warm muscle temperatures early post mortem [10]. Warm muscle temperatures early *post mortem* could arise from increased subcutaneous fat, which can be associated with carcasses that have high levels of marbling [11]. A high early post mortem temperature can also denature muscle proteins, which could increase color reflectance either through structural alteration of the myofibrillar proteins [12] or increased water exudation [13, 14].

Previous studies have shown that meat color darkens as intramuscular pH increases [15]. In the present study, Prime rib eye muscle had the highest mean pH, but it was only 0.1 pH value greater than that of the other grades (Table 1). This increase in pH did not affect the color of the lean as the lean of rib eye muscles from the Canada A were not as red and bright than those of Canada Prime because they had decreased mean *a** and *b** values (Table 1). The lean of Canada A and AA LD muscles may be darker than that of Prime beef due an increase in the oxygen consumption rate by post-rigor beef muscle. The rate of oxygen consumption by beef is decreased by high early post mortem muscle temperature, and this contributes to an attractive bright red appearance of the exposed meat surface [16].

Differences in drip loss among grades were limited to trends only (P = 0.057). There was a trend toward rib eye muscle from the Canada A grade to have the most amount of drip loss (Table 1). There were significant differences among the grades for cooking loss, with ribs from the Canada Prime grade having a lower mean cooking loss than that of ribs from the A and AA grades (Table 1).

There was no differences in Warner-Bratzler shear force (WBS) values among the grades (P = 0.124) although there was a trend for beef from Canada Prime ribs to be more tender than that from ribs of the other quality grades. The differences in peak shear force between grades could become significant if 24 rather than 12 replicates were included in the study. A power analysis based upon the mean and the standard error observed for the dependent variables in the present study indicated that doubling the sample size would increase the statistical power of the experiment from 0.75 to 0.97 and would decrease the likelihood of a Type II error.

Table 1. Means of meat quality measurements from each of the Canada quality grades

	CANADA GRADES				
Analysis	A	AA	AAA	PRIME	Pr > F[1] SEM[2]
L*	36.3^{a}	36.8^{a}	35.9^{a}	39.4^{b}	0.0006 0.88
a*	18.5^{a}	19.2^{a}	20.3^{ab}	21.3^{b}	0.0734[6] 1.15
b*	2.9^{a}	3.6^{a}	3.6^{a}	5.9^{b}	0.0022 0.80
pH	5.4^{a}	5.4^{a}	5.4^{a}	5.5^{b}	0.0494 0.045
DL[3]	0.8^{a}	0.7^{ab}	0.6^{b}	0.5^{b}	0.0567[6] 0.080
CL[4]	17.2^{a}	18.7^{a}	15.9^{ab}	14.6^{b}	0.0017 0.70
WBS[5]	42.6^{a}	44.9^{a}	45.0^{a}	32.2^{b}	0.1240[6] 4.28

[1] Probability of the calculated F value with significance at P $\leq$ 0.05
[2] Standard error of the mean
[3] Drip loss expressed in %
[4] Cook loss expressed in %
[5] Warner–Bratzler shear force expressed in Newton.
[6] Pr > F is not significant at P $\leq$ 0.05, however this value is included in the table to indicate a possible trend if adequate number of samples are analyzed in the future.
[a, b] Means with different superscripts within a row are significantly different at P < 0.05 according to least square mean differences tests.

IV. CONCLUSION

This study indicated that LD muscles from Canada Prime had meat quality characteristics different from those of the other grades, suggesting that Prime is appropriately valued as a superior product. The lack of difference among LD muscles graded Canada A, AA and AAA suggested that LD from A and AA may be undervalued, but the low statistical power of the experiment dictates that this conclusion be viewed with caution. Further research on the quality grades is needed to adequately describe the eating quality of the beef from these grades so that a complete quality profile of Canadian beef can be achieved.

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