DISTRIBUTION OF MARBLING SCORE IN CULLED DAIRY BEEF IN CENTRAL THAILAND

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Abstract – This study aimed to investigate carcass and meat quality of culled dairy cows in central Thailand. A total of 217 culled 75.0% crossbred Holstein Friesian cows were fattened for 4 months by members of the Max Beef Cooperative in Nakhonpathom province. Carcasses were later aged in a chilled room at 0-4 ◦C for 7 d. Effects of slaughter weight and body condition score (BCS) on carcass quality and effect of marbling score on meat quality were analyzed. Results showed that average pH of dairy beef carcass had 45 min post mortem values at 6.29±0.33 and at 7 d of ageing at 5.64±0.24 for normal pH of quality meat. Beef had averaged shear force value of 3.97±0.18 kg and meat colors were L* value (Lightness) as 43.54, a* value (Redness) as 20.71 and b* value (Yellowness) as 7.44. Marbling score (grade 1-3) had no effect on shear force value or chemical composition of the meat such as moisture, protein and fat percentages. Culled cows with BCS of 5 had higher live weight (638.81 kg) and cold carcass weight (344.37 kg) than those with BCS of 4 and 3 (539.84 and457.53 kg; 288.82 and 244.69 kg, respectively) ($p<0.001$). There was no effect of BCS on %cold carcass weight and meat marbling score ($p>0.05$). Higher cold carcass weight and meat marbling scores were found as live weight increased ($p<0.001$). It was concluded that fattening culled dairy beef was acceptable for producing quality beef when cows were >650 kg of BW and BCS >3. Shear force value of culled dairy beef was 3.97 kg which is acceptable by consumers for meat tenderness.

Key Words – Carcass and meat quality, marbling score, culled cows beef.

I. INTRODUCTION

Farmers raising dairy cattle in Thailand have been facing several problems that included low production of milk by old dairy cattle, their reproductive system, mastitis and others. These problems forced dairy farmers to frequently cull undesirable cattle for as high as 45,000 animals per year from their farms (Animal Livestock Economic Research Group, 2009) and sold these culled dairy cows to middlemen at a very low price. These animals with good physical condition were then raised for meat, from medium sized to slightly fattened cows or fully fattened, and can be sold at a price of 85-100 baht as compared to the price prior to fattening at 70-75 baht per kilogram (Supphakitchanon et al., 2015) of quite healthy animals, high quality carcass and a quality that is acceptable by consumers. Aside from these, the carcass and meat qualities were not so different from those of beef cattle (Office of Agricultural Economics, 2010).

Culled cattle were fed by providing commercial feed produced from rough feed materials which were mixed at suitable portions (TMR, 10.6 MJ ME and 130 g CP per kg DM) and were given to animals at 1.6 + 0.05 kg/day for a period of 2 and 4 months producing 10% and 21% wider Longissimus muscle, respectively, and 14% and 70% more back fat, respectively. Marbling score based on European standards was 3.4 and 4.4, respectively, and back fat thickness was 3.0 and 3.7, respectively (Vestergaard, et al., 2007). Fattening involved an increase in intramuscular fat and also improvement of aroma, and flavor of rib eye muscle but with reduced labor in meat cutting, increased tenderness and juiciness of the meat (Francoet al., 2009;Vestergaard et al., 2007). This study, therefore, was conducted with the objective of investigating the effect of on-farm raising of culled dairy beef on carcass and meat quality.

II. MATERIALS AND METHODS

Two hundred and seventeen culled 75.0% crossbred Holstein Friesian cows were fattened for 4 month by members of the Max Beef Cooperative in Nakhonpathom province. Carcasses were aged in a chilled room at 0-4 ◦C for 7 d. They were culled because low milk production, mastitis and reproductive system problems. Fattening for a

period of four months with 17-19% crude protein diet and roughage (Napier grass, pineapple and corn husks, etc.). The slaughter and evisceration in Halal slaughterhouse at Ratchaburi province.

Carcass quality; slaughter weight and body condition score (BCS) were recorded. On the day after slaughter and evisceration, hot carcass weight, pH_{45min}, pH_{7d} were collected. Carcasses were aged in a chilled room at 0-4 ◦C for 7 d. Chilled carcass weight and marbling score level were collected.

Meat quality; muscle samples from longissimus dorsi between the 12^{th} and 13^{th} ribs were collected from right carcass sides and transported to the laboratory in order to measure the physical and chemistry properties.

The physical properties; The pH values were obtained 45 minute (pH_{45min}) and 7 d after slaughter (pH_{7d}) using Seven GoTM pH meter SG2 (Mettler Toledo, China). Meat colour (lightness (L*), redness (a*), yellowness (b*)) was measured at three spots 24 h after slaughter using chroma meter (Konica Minolta CR-410).

The Warner–Bratzler shear force described by Honikel (1998). Instrumental tenderness was measured on longissimus dorsi using Instron Universal Testing Machine Model 3343 (Instron Corporation, USA). Samples were thawed for 24 hours at 4 °C. Weights were recorded pre- and post-cooking. Boiling sample until an internal temperature of 70 °C. The internal samples temperatures were monitored using a thermocouple inserted into the geometric center of each sample. Samples were placed in a cooler at 4 °C and allowed to chill for a 24 h. Shearing of each sample was performed by a V-shaped cutting blade at a velocity of 500 mm/min. Peak shear force values were recorded and averaged for each chop.

Proximate composition analysis - meat samples were analyzed for moisture, dry matter, crude protein, and fat according to AOAC (1996). Statistical analyses were carried out by SAS (version 9.1; SAS Institute Inc., Cary, NC, USA).

III. RESULTS AND DISCUSSION

Analysis of culled beef especially the longissimus dorsi muscles, showed pH value of 4.5 that was increased to 6.29+0.33 after slaughter, which meant that there was no opportunity for the meat to be PSE (pale, soft and exudative) at pH_{7d} after ageing, pH was reduced to 5.64+0.24 (Table 1), indicating that beef did not become DFD (dark, firm and dry). Normally, pH value of good quality beef ranged from 5.40-5.59. At 24 hours after post mortem, pH value usually decreased (Jutarat et al., 2010). Culled beef had an average shear force of 3.93 kg (Table 1), which was well within the American standard where acceptance by consumers indicated values of not more than 3.9 kg to be considered tender (Morgan et al., 1993). When compared with other culled beef parts, it was found that shear force was at an average of 4.7 kg (Pacheco et al., 2011) Meat lightness (L*) of culled beef was measured at 43.54 while redness (a*) was 20.71 and yellowness (b*) was 7.44, which were found similar to values reported by Athit et al (2011) based on findings of the study on meat quality of fattened cows with L* at 39.52+0.54, a* at 21.35+1.37 and b* at 8.62+1.02 including the loin eye area of 71.31 (cm^2) Meanwhile, Wacharapon et al. (2012) found that culled beef with slaughter weight lower than 460, 460-520 and higher than 520 kg, had a loin eye area of 73.50 81.02and 91.41 (cm^2) respectively.

Table 1 Physical properties of longissimus dorsi of culled cows

Item list	culled cows (N=30)
Slaughter weight (kg/head)	572.93± 67.76
pH_{45min}	6.29±0.33
pH_{7d}	5.64±0.24
Meat color	
Lightness (L*)	43.54±3.60
Redness (a*)	20.71±6.08
Yellowness (b*)	7.44±1.89
Rib eye area (cm^2)	71.31±21.05
Warner-Bratzler shear force (WBSF) (kg)	3.97±0.18

Longissimus dorsi muscles of culled beef was found to have a percentage dry moisture and protein not significantly different but percentage fat of culled beef had the highest marbling score (grade 3), followed by grades 2 and 1, respectively (Table 2). Oler et al. (2015). reported that longissimus lumborum (LL) of grade 2 and 3 marbling score contained less dry matter ($P < 0.05$) relative to grade 4 and 5 marbling score. Total

protein and total collagen content in the muscle was not influenced by marbling class. The most significant level of LL fat was found in grade 4 marbling score and the lowest in grade 2 marbling score. In turn, grade 5 marbling score of marbling the value of shear force was lowest (P <0.05) compared with remaining classes. Gołębiewski and Brzozowski (2011) reported that culled cow had dressing percentage of 48.13%. The most culled cows were qualified marbling score to grade 2 and 3 (80%). Noidad et al. (2014) reported that culled dairy cows (weight of 675.24 kg) showed the highest in hot carcass weight, cold carcass weight and skin weight. The most of them were qualified marbling score to grade 2 and 3 (73.6%).

Table 2 Chemical compositions of longissimus dorsi of culled cows

Item list	Marbling score		
	Grade 1	Grade 2	Grade3
Moisture (%)	67.11±1.53	68.09±4.85	66.59±4.26
Crude protein (%)	29.65±0.98	29.06±2.69	27.73±2.42
Crude fat(%)	7.00±2.16	9.20±2.81	12.67±3.36
Warner-Bratzler shear force (WBSF) (kg)	4.07	3.93	3.99

Table 3 Body condition score on carcass quality of culled cows

Item list	Body condition score		
	score3 (n=15)	score4 (n=112)	score5 (n=90)
Slaughter weight (kg)	457.53^{c} ± 23.0	539.84^{b} ± 29.6	638.81^{a} ± 42.2
Cold carcass weight (kg)	244.69^{c} ± 15.8	288.82^{b}± 18.6	344.37^{a}± 26.9
Cold carcass weight (%)	52.04 ± 1.9	52.75 ± 2.9	52.79 ± 2.8
Marbling Score	1.67 ± 0.8	1.74 ± 0.8	1.99 ± 0.8

a-c Means within row carrying no common superscripts are significantly different at P<0.05

Culled beef was found to have a body condition score of more than 3 (Table 3) because those culled beef cattle were fattened until they attained suitable weight for slaughter thus beef with a body score of 5 had an average live weight greater than cattle with body condition score of 4 and 3 (638.81, 539.84 and 457.53 kg/head, respectively (p<0.001), and average chilled carcass weight, with significant difference in statistics at (P<0.01).

However, chilled carcass percentage showed no significant difference in statistics (P<0.05) although meat of cattle beef of Grade 5 showed a higher marbling score than those of Grades 4 and 3 (P<0,061) (Table 3). Węglarz (2010) reported that heifers (Holstein-Friesian) had an average weight of 459.7 kg, aged 2.1 yearsm, dressing percentage of 53.3 and marbling score of 3.38.

In addition, live weight showed no effect on chilled carcass percentage of culled beef (P>0.05) but indicated that culled beef with body weight of more than 650 kg/head, had higher marbling score with significant difference in statistics (P<0.01) (Table 4).

Table 4 Slaughter weight on carcass quality of culled cows

Item list	Slaughter weight (kg)				
	< 500 (n=28)	501-550 (n=54)	551-600 (n=59)	601-650 (n=48)	>650 (n=28)
Slaughter weight (kg)	473.4^{e} ±24.3	526.1^{d} ±11.9	575.9^{c} ±15.2	621.1^{b} ±14.4	691.4^{a} ±32.7
Cold carcass weight (kg)	253.9^{e} ±17.5	281.2^{d} ±11.1	309.4^{c} ±14.7	332.2^{b} ±15.1	375.5^{a} ±21.4
Cold carcass weight (%)	52.3 ±2.3	53.1 ±3.46	52.4 ±2.4	52.6 ±2.6	53.2 ±2.9
Marbling Score	1.61^{b} ±0.9	1.74^{b} ±0.8	1.75^{b} ±0.8	1.92^{b} ±0.7	2.32^{a} ±0.9

a-e Means within row carrying no common superscripts are significantly different at P<0.05

IV. CONCLUSION

Culled dairy cattle raised for fattening proved to produce high quality beef. When used for fattening, body conditioning score must be at least 3 and body weight of more than 650 kg, would result to marbling score of 1-3 level with average meat shear force not different from the average value of 3.93 kg which consumers accept as tender meat.

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