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Ribeye areas and sizes of fattening culled dairy carcasses determination using plastic grid and geometric methods

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Abstract The ribeye areas (REA) of fattening culled dairy carcasses which measured using geometric method (GM) were significantly higher than those using plastic grid (PG) method with the averages of 84.12 and 81.42 sq.cm., respectively ($p<0.01$). The factor of ribeye sizes had highly significantly influenced on REA. The averages of REA for small, medium, and large sizes were 61.94, 80.85, and 105.51 sq.cm., respectively ($p<0.01$). In addition, the interaction between the fators of method and size affected on the REA. The averages REA of large size measured by GM method was 108.77 sq.cm higher than that measured by PG method 102.26 sq.cm. ($p<0.05$), whereas there was not significant difference for the small and medium sizes measured by both methods.

Keywords: Cross-section loin, Dairy beef, REA measurment methods

Introduction

Ribeye area is an important criterion to classify cattle carcass yield, which widely used in United State, Canada, Australia, Japan, etc (Tatum, 2020, MLA, 2018, CBGA, 2020, JMGA, 2000). Ultrasound equipment as well as computer tomography were applied to predict the area of *Longissimus dorsi* muscle of live animals (Luz e Silva *et al.*, 2003; Junkuszew and Ringdorfer, 2005). In the United State, ultrasonics was used to estimate both fat thickness and ribeye area since the 1950's (Lemaster, 1999). Nowsaday, many developed countries, such as European Union uses Video Image Analysis (VIA) technology to classify the beef carcasses from their shape and fat cover (AHDB, 2021), while Japanese Meat Grading Association (JMGA) had developed the digital camera technology and image analysis software (Beef Analyzer II) to calculate not only ribeye area but also other important traits such as ribeye shape, intramuscular fat percentage, meat color, fat color, and fineness/coarseness index marbling (AWA, 2021). In the United State and

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Australia graders put plastic grid on cross section of the ribeye muscle cut between 12th and 13th ribs to determine the area of the muscle directly (Tatum, 2020). However, cross section ribeye muscle can be traced on acetate paper for later area determination. There are various methods to evaluate the ribeye area such as planimeter, geometric, plastic grid, softwares (Yáñez *et al.*, 2006), video image analysis (Waylan *et al*., 1997), digital image (Ferreira *et al*., 2012), and color image (Nunes *et al*., 2015).

Beef carcass grading system consists of yield carcass grading and meat quality grading. In Thailand, yield carcass grading is not existed, only meat quality grading is available (ACFS, 2004). However, many academic publications studied ribeye area by tracing the boundary of the cross section ribeye region onto the paper or acetate sheet with permanent ink and then estimating it with various methods such as manual planimeter (Chongcharoen, 2003; Supphakitchanon, 2004; Prom-In, 2006), digital planimeter (Sukjai *et al*., 2012), leaf area meter (Karnjanasirm *et al*., 2019), and Iowa template or plastic grid (Kunya and Nattakan, 2017; Tuntivisoottikul and Worawong, 2017). Most studies described that it was an important trait which related with carcass traits. Some methods mentioned above used high cost equipments and time comsumed. Although plastic grid is used to evaluate the ribeye area directly on the chilled carcass in USDA standard and AUS-MEAT standard, but for routine work at slaughterhouse in Thailand it is quite not easy to train the workers to be evaluated technicians for counting and calculating the ribeye area. Furthermore, the plastic grid is not well-known used in Thailand compare with planimeter and leaf area meter, and it also has to be imported from the United State.

The maximum length and width of the cross section *Longissimus dorsi* muscle are used to determine the ribeye area in Canadian grading system (CBGA, 2020). The length and the width of the rib rye measured with ruler and principle of geometric are used to calculate the area. Due to the geometric method using easy and low cost instrument is used to evaluated ribeye area and academic documents concerning this method in Thailand is not found, thus it is interesting to investigate the possibility to use this method in routine practice comparing with plastic grid method. The objectives of this study were to determine the ribeye areas (REA) and sizes of fattening culled dairy carcass using geometric (GM) and plastic grid (PG) methods, study the factors of measuring method and size of ribeye influencing on the areas, and study the relationship between the areas measured with two methods and create prediction equation to estimate the REA.

Materials and methods

Animals, samples, and data collection

A total of two-hundred and thirty minimum % 75Holstein Friesian fattened crossbred dairy cattle consisted of steers, culled heifers, and culled cows were used to collect the sample. Data were carried out during 2019 to 2021. The animals were raised by the members of Beef Cluster Cooperative Ltd, located in Nakorn Phatom Province, Thailand. Male calves were weaned with the body weight was at least 50 kg and they could feed minimum 500 g roughage per day for 7 days. When their body weight reached about 200 kg they were castrated. During the first growing period which 10 to 15 months old they were fed with 16 % crude protein concentrate at about 3 kg per day and *ad libitum* fresh grass until their body weight was 200 to 300 kg. During the second growing period, 16 to 20 months olds, they were fed with 4 kg of 15 % crude protein concentrate per day until they reached 300 to 400 kg body weight. After that the finishing or fattening period was started, they received *ad libitum* 12 % crude protein Total Mixed Ration (TMR) until their body weight reached 600 kg (Sawanon, 2012). Fattening period was about 8 to 10 months. For the culled female dairy cattle, they were fattened for 4 to 6 months with 14% crude protein concentrate and were supplied with fresh grass, hay, fermented cassava, and pineapple by-products which differed from farm to farm. When their live weight reached approximately 500 to 700 kg, they were transported to a private slaughterhouse, Prakob Beef Products Co. Ltd., Banpong District, Ratchaburi Province. Before slaughtering they were fasted for10-12 hr and had *ad libitum* water supply. They were stunt with a captive piston pistol then slaughtered. Head, skin, internal organs, and hoofs were removed. Each carcass was cleaned and longitudinal dissection cut into halves. Carcasses were aged approximately 7 days in a 2° to 4°C chill room. At the 7th day of ageing, the left side of carcass between the 12th to 13th rib was cross-sected. An acetate sheet was placed on top of the area and the ribeye area and rib fat thickness were traced on the sheet with permanent ink. The traced acetate sheet was used as present studied sample.

Ribeye area determination

The ribeye area was evaluated by using two measuring methods. The first method was the plastic grid method which using grid or Iowa template adapted from Tatum (2020). The plastic grid was put on the acetate sheet then counted all squares in which lean surrounds a dot. Measurement was made by addition of all squares found inside of the ribeye tracing perimeter and those that where in the contour of the tracing passed through the middle dot. Resulting number was the area of the ribeye in square inches. For present study, the area was changed to be square centimeters by multiplying with 2.54 x 2.54. The second method was geometric method. The maximal width of *M. Longissimus dorsi* on acetate sheet, namely "A", and the maximal length of the muscle on acetate sheet, namely "B", were measured. Based on total area of ellipse, the ribeye area was calculated by using following equation: $(A/2 \times B/2) \times \pi$, where "A" was the maximal width of *M. longissimus dorsi*, "B" was the maximal length of the muscle, and π was constant value equaled to 3.1416 (Ferreira *et al*., 2012). All acetate sheets were measured twice for each method.

Data analysis

Data distribution was studied using descriptive statistics. Due to ribeye area were measured from two methods, Z-score was used to classify REA size. The Z-score distribution with mean equaled 0 and standard deviation (SD) ranged from -1 to + 1 from both methods were classified as medium size. Whereas, the SD less than -1 the size of ribeye was categorized as small size and the SD more than +1 was the large size as shown in Table 1. The factors of 2 methods (plastic grid, and geometric), sizes (small, medium, and large), and interaction between methods and sizes affecting ribeye area were analyzed by using general linear model with interaction as shown in the model. Statistical analysis was done using SPSS software (IBM Corp. Released 2011).

$$Y_{ijk} = \mu + M_i + S_j + MS_{ij} + e_{ijk}$$

Where: Y_{ijk} is the REA trait of observed animals; μ is overall mean; M_i is fixed effect of measuring methods of animal i^{th} (i=1, 2, when 1=PG, 2=GM), S_j is fixed effect of REA size j^{th} (j = 1, 2, 3, when 1 to 3 were 1= small, 2= medium, and 3= large), MS_{ij} is fixed effect of the interaction between the method and the size effects, e_{ijk} is random effect of residual. If there was significant variance in F test ($p<0.05$), differences of the marginal means would be displayed by using the Bonferroni (IBM Corp. Released 2011). Pearson correlation was used to study the relationship between the area measured with 2 methods and prediction equation to estimate the REA was analyzed.

Mean, standard deviation, and number of samples of different REA sizes from 2 measuring methods are shown in Table 1.

Table 1. Ribeye areas distribution according to the measuring methods and REA sizes factors

Methods	Sizes	Mean (sq.cm.)	Std. Deviation	N
Plastic grid	Small	62.27	4.96	34
	Medium	79.73	7.34	159
	Large	102.26	6.64	37
	Total	80.77	13.18	230
Geometric	Small	61.61	4.91	34
	Medium	81.98	7.23	160
	Large	108.77	8.39	36
	Total	83.16	14.95	230

Results

The distribution of ribeye area measured with plastic grid and geometric methods are shown in Table 2. The area ranged between 50.97 and 121.94 sq.cm. for those measured with PG and ranged from 50.16 to 136 sq.cm. for those measured with GM.

Table 2. Descriptive Statistics of the studied data

Methods	Mean (sq.cm.)	Std. Deviation	Minimum	Maximum
Plastic grid	80.77	13.18	50.97	121.94
Geometric	83.16	14.95	50.16	136.00

The P-values of studied factors affecting REA are shown in Table 3. All the factors had highly significantly influenced the ribeye area ($p<0.01$) The adjusted R-squared of the studied model was 0.752.

Table 3. P-values and adjusted R squared of the studied factors influenced the ribeye area

Trait	P-values of studied factors			Adjusted R^2
	Method (M)	Size (S)	MxS	
Ribeye area	0.0013	0.0000	0.0092	0.752

The average of REA measuring by geometric method was 2.7 sq.cm. higher than those evaluating with plastic grid, 84.12 and 81.42 sq.cm., respectively (Table 4). The large size had the highest mean of REA (105.51 sq.cm.), while the small size had the lowest mean (61.94 sq.cm.), as shown in Table 4.

Table 4. Mean±standard error of the REA according to the main effects of measuring methods and REA sizes

Trait	Measuring methods		REA sizes		
	Plastic grid	Geometric	Small	Medium	Large
REA (sq.cm.)	81.42±0.59	84.12±0.59	61.94±0.85[a1/]	80.85±0.39[b]	105.51±0.82[c]

1/: Different superscript letters indicate significantly different values within each column ($p<0.01$).

The means and standard errors of the interaction between the measuring method and the size effected the ribeye area is shown in Table 5. The mean which measured with plastic grid method with small size (62.27 sq.cm.) was closely to the average of the same size, measuring with gemetric method (61.61 sq.cm.). The similarly results was found in the medium size, measuring with the plastic method and geometric method, which the averages of 79.73 and 81.98 sq.cm., respectively. It was interested that the large size of REA measuring with plastic grid was approximately 6 sq.cm. lower than those measuring with geometric method ($p<0.01$), as seen in Figure 1.

Table 5. Mean±standard error of the interaction factors between the measuring methods and the sizes on the REA

Measuring Methods	Sizes	REA Mean±Standard error
Plastic grid method	Small	62.27±1.21
	Medium	79.73±0.56
	Large	102.26±1.16
Geometric method	Small	61.61±1.21
	Medium	81.98±0.56
	Large	108.77±1.18

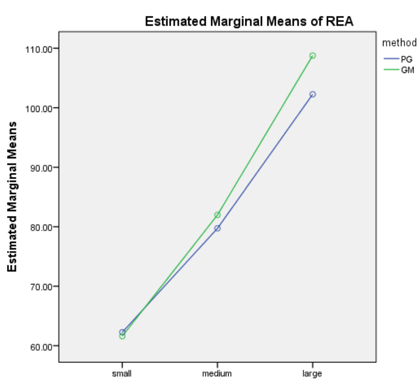

Figure 1. The effect of interaction factor between measuring methods and sizes on REA

Discussion

Ferreira *et al.* (2012), who studied different methods to determine REA in sheep carcasses, reported that the area which measured by using dimensions “A” and “B” method (namely geometric method (GM) in present study), was significantly higher than those measured with digital image, planimeter, and plastic grid ($p<0.05$). Our result was also detected that the REA measured with GM was higher than those measured with PG ($p<0.01$). Moreover, the authors found that the average REA measured with “A” and “B” dimensions was 2.23 sq.cm. higher than those measured by the plastic grid. Although Ferreira *et al.* (2012) studied in sheep carcasses, but it was interesting that their results were similarly to this current study which done in dairy carcasses sample. The average of REA measured by GM was significantly higher (2.7 sq.cm.) than those measured by PG. Furthermore, the correlation coefficient between the REA measured by the two methods was 0.837 which closely to the Ferreira *et al.* (2012) study ($r=0.88$).

The ribeye size is an important criterion in the USDA Yield Grade equation that indicates relative red meat yield of the carcass. Ribeye size is related to carcass weight with the ribeye size generally increasing as carcass weights get heavier (McKinnon, 2000). It was interesting that the report was in accordance with Sukjai *et al.* (2012), who found that the area of ribeye muscle from culled dairy cows carcass, which measured by using planimeter was the highest REA found in the animals which their slaughter weight was heavier than 520 kg (91.41 sq.cm.) and the lowest REA (73.50 sq.cm) was found for the weight less than 460 kg. Unfortunately, the relationship between the REA-size and carcass weight or slaughter weight in this current study was not available.

The average of REA measuring with GM in this present study was overestimated when compared with PG. However, the GM was easier and less time consumed than those evaluated with PG method. The REA measured by PG could be estimated by prediction equation which was $REA\_PG = 0.738(REA\_GM) + 19.376$, as shown in Figure 2.

This study was found that there was statistically significantly interaction between measuring methods and size on ribeye areas ($p<0.01$), especially the REA of large size measuring with GM method was higher than PG method but not for small and medium sizes. The reasons could be because the large sized of ribeye had more length and width than the other sizes and due to the REA was calculated based on elliptical area formular.

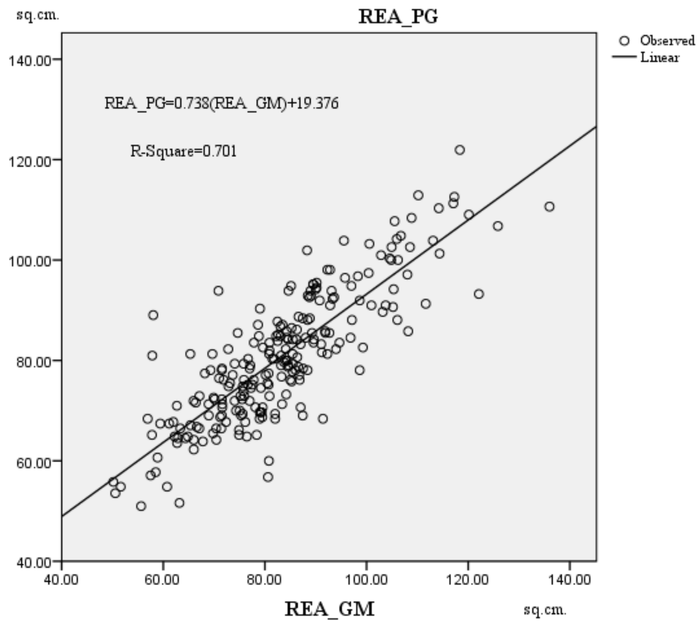

Figure 2. Regression line and prediction equation of REA

Canadian Yield Ruler is used to classify the yield grade of carcasses in Canada by combining muscle score with fat class score and the 5 yield classes. The muscle score consisted of 3 categories, which is obtained from measuring the maximum length of the ribeye muscle and the maximum width of the muscle between the 12^{th} and the 13^{th} ribs (CBGA, 2020). These indicated that the GM method can be used at slaughter plant.

As indicated before, beef carcass grading as yield grade in Thailand is not official set up. To establish the yield grade carcass classification, ribeye area should be considered as an important trait. The geometric method could be used at slaughter plant because it is a practical and economical method. However, the measuring of length and width positions of the trace on acetate paper sheet must be well detailed and the technicians in the slaughter plant must be trainned.

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