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Yield grading and prediction of combined closely trimmed and semi-boneless lean percentage using carcass traits of fattening culled dairy cattle in Thailand

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Abstract The percentages of combined closely trimmed and semi-boneless lean of fattening culled dairy carcass were classified into five yield grades, 1 through 5. Yield grade 1 carcasses had the highest semi-boneless lean percentage more than 81 % and yield grade 5, the lowest percentagde which combined in closely trimmed semi-boneless lean was less than 68. A significant regression equation was found ($F = 13.321$, $p < 0.05$), with an R^2 of 0.305. The equation for predicting the combined in closely trimmed and semi-boneless lean percentage of fattening culled dairy carcass is combined in closely trimmed and semi-boneless lean percentage was 81.523 – 0.851 (marbling score, 1-5) – 1.209 (rib fat thickness, cm.) – 0.097 (chest cavity width, cm.) + 0.060 (rib-eye area, square cm.) + 1.302 (sex, 0=male, 1=female).

Keywords: Dairy carcass traits, Combined closely trimmed and semi-boneless lean grading, Marbling score, Rib fat thickness, Rib-eye area

Introduction

Local cattle and buffalo markets are located in many provinces of Thailand. Traders inside the markets consisted of buyers, sellers, and dual-purpose traders whose trading was facilitated by the owner or the manager of the market. The price of animals depended on their live weight, gender, age, and body shape, which the buyers estimated the traits via visual judgment (DLD, 2012). Number of local cattle and buffalo markets was decreased from 175 in 2012 (DLD, 2012) to 123 places in 2020 (DLD, 2020), with the reason that the number of beef cattle was decreased. Hence, there is deficient beef for consumption, therefore dairy beef has become an alternative to solve the problem. To supply beef demand, the fattened dairy carcasses; steer, culled heifers, and culled cows are used to produce beef suggested by Osothong *et al*. (2016).

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Beef carcass grading system is widely used. In European Union, video image analysis is used to evaluate body conformation and beef quality (Dlamini *et al.*, 2020), while in the United State, both yield carcass grading (USDA grades) and meat quality grading are operated (Tatum, 2020). However, beef carcass grading system in Thailand, especially yield grading is not existed. Cold carcass mass and marbling score, followed the ACT 6001-2004 Beef Standard, are the main criteria to determine the price of carcass in commercial beef producers (ACFS, 2004). However, the price of the fattening culled dairy carcass is 5 to 20 Baht/kg lower than that of the fattening beef carcass (Max Beef, 2021) because the fattening dairy cattle carcass has less loin eye area and carcass percentage than the fattening beef cattle carcass (Tuntivisoottikul and Worawong, 2017).

Beef Cluster Cooperative Limited (Max Beef) is a private beef production company, where the fattening culled dairy beef is produced. Cold carcass mass, marbling score followed the ACT Beef Standard, and age of dairy cattle are used as criteria for trading price. According to no yield grading system for fattening culled dairy carcass or even beef carcass in Thailand, this study was done to establish yield grades standard and develop a prediction equation for fattening culled dairy as combined in closely trimmed and semi-boneless lean percentage in carcass which could be used to set yield grading system for fattening culled dairy carcass. The results could be used to help setting prices for farmers who raise fattening culled dairy cattle fairly when compare with using beef cattle standard.

Materials and methods

Animals, samples, and data collection

The fattened dairy cattle; minimum % 75Holstein Friesian blood steers, culled dairy heifers, and culled cows were raised by the members of Beef Cluster Cooperative Ltd, in provinces such as Nakorn Pathom, Ratchaburi, and the others during 2019-2021 used as population in this study. They were fattened for 4-6 months with 14% crude protein concentrate, fresh grass, hay, fermented cassava, and pineapple by-products which varied from farm to farm. They were slaughtered at their live weight reached approximately 500 to 700kg at the commercial slaughterhous in Ratchaburi Province.

Before slaughtering they were fasted for 10-12 h but had *ad libitum* water to drink. Before and after slaughtering, the 13 variables which easily obtained from field data collection were recorded. The age of animal was identified by counting their permanent incisor teeth. The first, second, third, and forth pair

appeared meant they were 1½ to 2, 2½ to 3, 3½ to 4, and >4½ years old, respectively (Taylor, 1984).

A captive piston pistol was used to stunt the animals then they were slaughtered. Head, skin, internal organs, and hoofs were removed and weighed. Each carcass was cleaned and longitudinal dissection cut into two half. The carcasses were weighed as hot carcass weight and they were measured the length and the chest cavity width. Then they were aged approximately 7 days in a 2° to 4° C chill room. At the seventh day of ageing, both carcass sides were weighed again as cold carcass weight, then the left side of carcass was cross-sected between the ribs 12^{th} to 13^{th}. The *longissimus dorsi* (LD) muscle was used to assess the five marbling score levels following the TACFS 6001 - 2004 Beef Standard (ACFS, 2004). Longissimus area (rib-eye area, REA) and rib fat thickness at the 12^{th} rib were measured as followed Tatum (2020).

The carcasses were dissected and trimmed at carcass cutting plant in Kampangsan distric, Nakorn Pathom province. The left side carcass was dissected into several sub-primal cuts, and all bones were removed except T-bone and rib bones. After the de-boning, the excessive fat and inter-muscular fat were closely trimmed. All sub-primal cuts were summed and calculated as combined closely trimmed and semi-boneless lean percentage (%CTSBL) in carcass based on cold carcass weight. The samples in this study were 293 fattening dairy cattle (114 steers, 179 culled heifers, and culled cows). Yield of the carcasses were used to identify as percentage of combined closely trimmed and semi-boneless lean grading, and all 12 independent variables (mentioned-detail in data analysis) were used to develop a prediction equation for combined closely trimmed and semi-boneless lean percentage in carcass of culled dairy cattle in Thailand.

Data analysis

To analyze the percentages of combined closely trimmed and semi-bonless lean as yield grades, descriptive distribution such as grouped frequency distribution was used. The independent or predictor and the dependent variables recorded in this study were 1) sex (male and female), 2) marbling score (1-5), 3) pair of teeth (1-4), 4) live weight (kg.), 5) hot carcass weight (kg.), 6) cold carcass weight (kg.), 7) skin weight (kg), 8) loss weight (kg), 9) chest cavity width (cm.), 10) carcass length (cm.), 11) rib-eye area or REA (square centimeter), 12) rib fat thickness (cm.), and 13) combined closely trimmed and semi-boneless lean percentage (%CTSBL). This data set was also assigned to verifying the prediction equation developed. All the statistical analyses, including the descriptive statistics and stepwise regressions were performed.

The value $p < 0.05$ was considered statistically significant. Statistical analysis was done by using SPSS software (IBM Corp. Released, 2011).

Results

Carcass classification

The average and standard deviation of combined closely trimmed and semi-boneless lean percentage (%CTSBL) was 77.0±2.6, which the minimum and maximum of the traits were 64.5 and 83.4, respectively. Grouped frequency distribution of %CTSBL data of fattening dairy carcasses are shown in Table 1. Rank of the trait was devided into 5 classes. Most animals (154 heads) were in class 4th which the %CTSBL ranged from 76.5 to 80.5.

Table 1. Descriptive statistics of combined closely trimmed and semi-boneless lean percentage in fattening dairy carcasses (n=293)

Rank	Range (%)	Mid-point (%)	Frequency (heads)
1	64.5-68.5	66.5	2
2	68.5-72.5	70.5	13
3	72.5-76.5	74.5	102
4	76.5-80.5	78.5	154
5	80.5-84.5	82.5	22

Yield of dairy beef carcasses were classified into five grades, 1 through 5, as shown in Table 2. Yield grade 1 carcasses had the highest of %CTSBL ≥ 81 and yield grade 5 had the lowest which %CTSBL ≤ 68.

Table 2. Yield grading of fattening dairy carcasses identified by combined closely trimmed and semi-boneless lean percentage (n=293)

Grade	combined closely trimmed and semi-boneless lean percentage	
	Range	Mid-point
1	≥ 81	82.5
2	77-80	78.5
3	73-76	74.5
4	69-72	70.5
5	≤ 68	66.5

Prediction of combined closely trimmed and semi-boneless lean percentage

A multiple stepwise linear regression was calculated to be an equation to predict combined closely trimmed and semi-boneless lean percentage based on their marbling score, rib fat thickness, chest cavity width, REA, and sex, as

shown in Table 3. A significant regression equation was found ($p< 0.05$) with an R^2 of 0.305 and a standard error of 2.199. Five independent variables for predicting combined closely trimmed and semi-boneless lean percentage is equal to 81.523 – 0.851 (marbling score) – 1.209 (rib fat thickness, cm) – 0.097 (chest cavity width, cm) + 0.060 (REA, sq.cm.) + 1.302 (sex), where marbling score is coded as 1-5, rib fat thickness and chest width cavity are coded as cm., REA is code as square centimeter, and sex is coded as 0 = male and 1 = female. Combined closely trimmed and semi-boneless lean percentage decreased 0.851 % for each marbling score increased, decreased 1.029 % for each centimeter of rib fat thickness increased, decreased 0.097 % for each centimeter chest cavity width increased, increased 0.060 % for each square centimeter of REA increased, and females' combined closely trimmed and semi-boneless lean percentage increased 1.302 % more than males. Five independent variables were significant predictors of combined closely trimmed and semi-boneless lean percentage.

Table 3. Effect of fattening cull dairy cattle carcass variables on the combined closely trimmed and semi-boneless lean percentage in carcass (n=293)

Predictors	Coefficient	Std. error	t-ratio	Sig.
Constant	81.523	1.820	44.782	0.000
Marbling score	-0.851	0.258	-3.295	0.001
Rib fat thickness	-1.209	0.330	-3.657	0.000
Chest cavity width	-0.097	0.022	-4.335	0.000
Rib eye area	0.060	0.014	4.248	0.000
Sex	1.302	0.375	3.644	0.000

R^2 = 0.305, F ratio = 13.321, p-value = 0.000, Standard error = 2.199

Discussion

Beef carcass grading is classified into yield grading and quality grading. Yield grading system is different from country to country. More than 90 % of beef carcasses in the European Union are identified by video image analysis (Dlamini *et al.*, 2020). In the United State, USDA yield grade is evaluated from combining yield of the closly trimmed with boneless retailed cuts of beef or four primal cuts which are chuck, rib, loin, and round. It is known as the percentage retail yield or percentage of closely trimmed boneless retail cuts (%CTBRC). The lower the numerical value of the USDA yield grade the higher the yield of closely trimmed boneless retail cuts (%CTBRC) such as yield grade 1 carcasses have the highest yield of retail cuts more than 52.3 %CTBRC and yield grade 5 which the lowest %CTBRC is less than 45.4 (David and William, 2007, Tatum, 2020).

In Thailand, only quality grading system of beef carcass is used. The meat color, fat color, age of animals (dentity), and marbling score are used to estimated the quality grade. Meat quality is divided into five grades: prime, choice, select, commercial, and utility (ACFS, 2004). Beef carcass grading system, especially yield grade has never established. Data set from this study was collected from routines works of the Beef Cluster Cooperative Ltd, therefore the carcass yield grades were categorized into five grades and as known as percentage of combined closely trimmed and semi-bonless lean (%CTSBL), which calculated from trimmed meat and retail cut of four primal cuts: chuck, rib with bone, loin with T-bone, and round based on cold carcass weight. The yield grade 1 has the highest percentage of lean (≥81%), while the grade 5 has the lowest percentage of lean (≤68%). Although our sample were dairy beef, however, results from this study was closely to Jones and Stringer (2007), who reported that USDA yield grade, the total percent retail cuts (combined lean of closely trimmed and semi-boneless) of carcass was 82 for grade 1 and 63.6 for grade 5. They also reported the percentage of trimmed and semi-boneless lean which separated from forequarter and hindquarter of mostly beef cattle carcasses.

Meat Standard Australia (MSA) used many criteria, such as breed (Brahman), sex, maturity (ossification), carcass weight, maturity, hanging methods, marbling, rib fat, ribeye area, etc for beef grading system (MLA, 2017), while European Beef Grading System (EUROP) used three factors; carcass weight, carcass conformation, and rib fat measurement for the beef grading system. In the United State, beef carcass grading system is based on the four factors: hot carcass weight, fat thickness at the 12^{th} rib, percent of kidney, heart and pelvic fat, and rib-eye area (David and William, 2007). For present study, it found that five factors, which are marbling score, rib fat thickness, chest cavity width, rib-eye area, and gender were used in the equation for predicting the combined closely trimmed and semi-boneless lean percentage, which the coefficient of determination (R^2) of 0.305 (30.5%). It was interested that the R^2 of present study was higher than those reported by Lee *et al.* (2015), who also used the same regression method; stepweise, to create the prediction equation of retail cut percentage of Hanwoo steer using carcass grading traits. They found that the percentage of R^2 for the retail cut percertage ranged from 10.7 to 23.5, which was lower than our study. It may be because of the reasons that in their study had the different type of cattle and the less numbers of independent variables compared with this study.

In conclusion, the yield grading for dairy beef carcasses and the prediction equation for combined closely trimmed and semi-boneless lean percentage would be applied for judging the carcass price, so that the farmers

who raised and fattened the cull dairy cows or heifers and steers will get the fairness in the dairy beef trading. Moreover, the yield grading system for beef carcass in Thailand should be imperative established.

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