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Gender, age, farm, and slaughter month factors affecting dairy carcass traits and the relationship between the traits, thoracic cavity depth, and carcass length

Thawonwat, R.[1], Sivapirunthep, P.[1], Kongpiboon, W.[2] and Tuntivisoottikul, K.[1*]

[1]Department of Agricultural Education, Faculty of Industrial Education and Technology, King Mongkut's Institute of Technology Ladkrabang, Bangkok, 10520, Thailand; [2]Department of Industrial Education, Faculty of Industrial Education and Technology, King Mongkut's Institute of Technology Ladkrabang, Bangkok, 10520, Thailand.

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Abstract Farm affected most traits, except for the thoracic cavity depth (TCD), skin weight (SKW) and percentage of skin weight (PSK). Slaughter month had affected all the traits, except for PSK. The relational study, findings showed that the final live weight had highly significant positive correlated with all studied traits ($P<0.01$), except for TCD and PSK. Hot carcass weight had highly significant positive correlated with dressing percentage of carcass length (CL) and SKW ($P<0.01$), except for PSK. Dressing percentage did not correlate with TCD and CL. However, the negative correlation between TCD and CL ($r = -0.325$) was found, whereas the TCD had no correlation with SKW and PKW. However, CL had negative correlation with PSK ($r=-0.287$), while the relationship between SKW and PSK was 0.586.

Keywords: Dairy cattle, Dairy steer, Culled dairy heifer or cow, Carcass traits

Introduction

In the dairy industry, cows are used to produce milk. Male calves will not grow up to produce milk, thus they are considered of little value to dairy farmers and are sold for beef production. In general, not only male calves, but culled dairy heifers and cows are also fattened to produce meat. Heifers and cows are culled for many reasons, such as infertility, negative milk yield and diseases where mastitis is most commonly found. Currently, about 20% of dairy beef make up for the lack of beef demand in Thailand (Sethakul, 2016). Beef Cluster Cooperative Limited (Max Beef) is one of Thailand's major beef producers. Not only do they produce beef from beef cattle, but also from their dairy cattle or their crossbreds (both dairy crossbreds and dairy cow x beef sire crossbreds). These cattle farmers raise different types of cattle. Some raise only beef and/or dairy cattle, while

[*] **Corresponding Author:** Tuntivisoottikul, K.; **Email:** kunya.tu@kmitl.ac.th

some would buy male dairy calves to grow and fatten them in beef cattle farms. Approximately 25 % of total slaughter animals per year from the Cooperative are from fattened dairy cattle. There are many factors that affect the dairy carcass characteristics and meat quality, such as gender, age, and farm management. (Guerrero *et al.*, 2013). Many researches that use morphometric measurements in livestock are published abroad (Coopman, 2008; Torrescano *et al*., 2010; Assan, 2013). Researches concerning factors affecting dairy cattle carcass in Thailand are found to be insufficient, and at the same time, documents using morphometric traits in dairy carcass characteristics, especially thoracic cavity depth and carcass length, are also still limited. Therefore, the objectives of this study were to determine the effects of gender, age, farm, and slaughter month on dairy carcass traits and to study the relationship between the traits, thoracic cavity depth, and carcass length.

Materials and methods

Many dairy steers and culled dairy cows were raised by the members of Beef Cluster Cooperative Ltd, Nakorn Pathom Province. They had minimum 75 % Holstein Friesian blood. The dairy steers (male) and culled animals (heifers and cows, female) were raised and intensively fattened with 14% crude protein concentrate, and were supplied with fresh grass, hay, fermented cassava, pineapple by-products (may vary within each farm) for 4 to 6 months until their final live weight reached approximately 500-700 kg., which were then transported to the commercial slaughterhouse in Ratchaburi Province. They received *at libitum* of water without feeding for 10 to 12 h before slaughtering.

During January to June 2019, researchers collected data from 59 fattened dairy steers and culled dairy heifers or cows which from 13 farm members.

Data of gender, farm, and slaughter month of the animals were recorded before slaughtering. The animals were stunned with a captive piston pistol and then slaughtered. Age assessment was done by identifying their teeth and by using permanent incisors: 0 pair for milk teeth less than 2 years old, first pair is 1½ to 2 years old, second pair is 2½ to 3 years old, third pair is 3½ to 4 years old, fourth pair is 4½ to 5 years old (Taylor, 1984). After removing of head, skin, internal organs, and hoofs, each carcass was cleaned, and then halved into 2 sides. Left and right hot carcass were weighted and recorded. Percentage of skin weight was computed by divided skin weight with final live weight, while dressing percentage was calculated by dividing hot carcass weight with final live weight, and then multiplied by 100.

On the left side of the carcass, thoracic cavity depth and carcass length were examined and recorded. The thoracic cavity depth was measured from

the ventral edge of the spinal canal of the seventh thoracic vertebra to the ventral edge of bone on the plate with a measuring tape. This was done while the carcass length was measured from the anterior edge of the first rib right up against the vertebral column to the acetabular branch of the pubis on the aitch bone (Orts, 1959) shown in Figure 1.

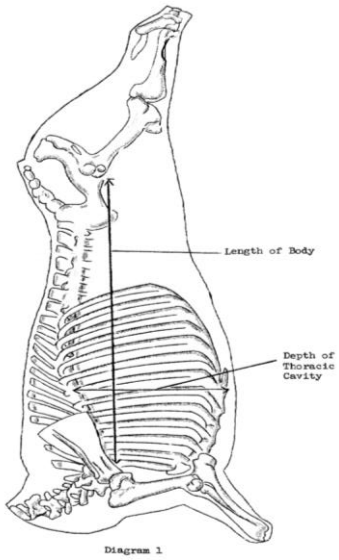

Figure 1. The measurement positions of thoracic cavity depth and carcass length. Source: Orts (1959)

Carcass traits were final live weight, hot carcass weight, dressing percentage, thoracic cavity depth, carcass length, and skin weight. Distribution of the studied traits data were analyzed by using descriptive statistics, such as mean, standard deviation, minimum and maximum. To determine the effect of gender, age, farm, and slaughter month; least squares method was used to analyze the influence of gender, age, farm, and slaughter month on the studied traits, as shown in the following statistic model:

$$Y_{ijklm} = \mu + S_i + A_j + F_k + Slm_l + e_{ijklm}$$

Where: Y_{ijkl} was studied traits, μ was overall mean, S_i was fixed effect of gender i^{th} (i=1, 2), A_j was fixed effect of age j^{th} (j= 1, 2, 3, 4), F_k was fixed effect of farm k^{th} (k=1, 2, 3,….., 13), Slm_l was fixed effect of slaughter month l^{th} (l=1, 2, 3,…,6), e_{ijklm} was random effect of residual. Pdiff option was used to compare the difference of least squares means (SAS, 1999).

Pearson product-moment correlation was used to analyze the relationship between the carcass traits, thoracic cavity depth, and carcass length.

Results

Final live weight of fattened dairy cattle in this study ranged from 427 kg to 793 kg with the average and standard deviation of 631.78±81.15 kg, as shown in Table 1. The average hot carcass weight and dressing percentage were 345.64±53.07 kg and 54.58±2.75 %, respectively. The average thoracic cavity depth and carcass length were 48.58±5.17 cm and 146.92±13.07 cm., respectively. The skin weight had an average of 38.44±6.22 kg, which ranged from 29 to 53 kg. Percentage of skin weight were between 4.34 to 8.18 %.

Table 1. Mean, standard deviation (SD), minimum, and maximum of dairy carcass traits (N=59)

Traits	Mean	SD	Minimum	Maximum
Final live weight (kg)	631.78	81.15	427.00	793.00
Hot carcass weight (kg)	345.64	53.07	235.00	450.50
Dressing percentage (%)	54.58	2.75	49.96	61.32
Thoracic cavity depth (cm)	48.58	5.17	32.00	61.00
Carcass length (cm)	146.92	13.07	120.00	183.00
Skin weight (kg)	38.44	6.22	29.00	53.00
Skin weight (%)	6.15	0.78	4.34	8.18

The influence of studied factors was shown in Table 2. There was no significant difference of gender and age on final live weight, hot carcass weight, dressing percentage, thoracic cavity depth, carcass length, and skin weight ($P>0.05$). In contrast to the factors of farm and slaughter month, the results showed that the factor of farm significantly had an effect on their final live weight, hot carcass weight, dressing percentage, and carcass length ($P<0.05$). Interestingly, the slaughter month had an effect on all of the traits studied $P<0.05$), except percentage of skin weight ($P>0.05$).

Table 2. P-values of factors (gender, age, farm, and slaughter month) and R square on study traits

Traits	P values				R square
	Gender	Age	Farm	Slaughter month	
Final live weight (kg)	0.5242	0.6651	0.0006	0.0060	0.6883
Hot carcass weight (kg)	0.5096	0.3658	0.0003	0.0015	0.7292
Dressing percentage (%)	0.6594	0.2894	0.0030	0.0284	0.6701
Thoracic cavity depth (cm)	0.4001	0.3744	0.2822	0.0001	0.6702
Carcass length (cm)	0.6178	0.1478	0.0468	<.0001	0.7039
Skin weight (kg)	0.6687	0.1701	0.1432	0.0326	0.5178
Skin weight (%)	0.9532	0.1452	0.5497	0.6464	0.4472

Effects of gender

Although the gender factor had not significantly influenced in all studied traits ($P>0.05$), the LS means and standard errors of the traits are

shown in Table 3. Dressing percentage of female and male were 55.30, and 54.84 %, respectively. Their thoracic cavity depths were 47.12 and 45.43 cm, for female and male, respectively, while the carcass lengths were 148.63 cm for female and 146.23 cm for male. The average skin weight of female was 43.56 kg, while that of male was 42.13 kg, whereas both genders had similar percentage of skin weight (6.75 and 6.78 %, for female and male, respectively).

Table 3. Least squares means and standard errors of carcass traits, according to gender

Carcass traits	Female	Male
	LSM ±SE	LSM ±SE
Final live weight (kg)	644.83 ± 23.68	625.30 ±24.78
Hot carcass weight (kg)	357.57 ±14.43	345.24 ±15.10
Dressing percentage	55.30 ±0.83	54.83 ±0.86
Thoracic cavity depth (cm)	47.12 ±1.55	45.43 ±1.62
Carcass length (cm)	148.63 ±3.72	146.23 ±3.89
Skin weight (kg)	43.56 ± 2.47	42.13 ±2.69
Skin weight (%)	6.75 ±0.39	6.78 ±0.36

Effects of age

Factor of age had not influenced in all studied traits. However, the average of final live weight, hot carcass weight, dressing percentage, and carcass length among the four-years-old cattle were higher than others. The oldest stock showed a greater average of thoracic cavity depth (49.08 ±1.16 cm), with lower averages of skin weight both in kilograms and in percentage (37.75 ±2.00 kg, and 6.08 ±0.27 %, respectively).

Table 4. Least squares means and standard error of studied traits, according to age

Traits	Age			
	2 yrs old LSM ±SE	3 yrs old LSM ±SE	4 yrs old LSM ±SE	≥5 yrs old LSM ±SE
Final live weight (kg)	630.56 ±72.56	630.21 ±47.43	654.93 ±25.95	624.56 ±17.72
Hot carcass weight (kg)	340.10 ±44.22	354.21 ±28.91	369.30 ±15.82	342.00 ±10.80
Dressing percentage	53.62 ±2.53	55.98 ±1.65	56.17 ±0.91	54.48 ±0.62
Thoracic cavity depth (cm)	42.08 ±4.76	46.74 ±3.11	47.19 ±1.70	49.08 ±1.16
Carcass length (cm)	139.81 ±11.39	147.60 ±7.44	155.48 ±4.07	146.81 ±2.78
Skin weight (kg)	43.75 ±7.14	48.19 ±4.69	41.69 ±2.65	37.75 ±2.00
Skin weight (%)	7.05 ±0.96	7.62 ±0.63	6.32 ±0.36	6.08 ±0.27

Effects of farm

The least squares means and standard errors for significant effects of farm on studied traits are shown in Table 5. Farm 11 showed the highest final live weight (749.77 ±42.48 kg), while the lowest was found in farm 2

(484.59±40.58 kg). The average of hot carcass weight of cattle from farm 12 was the highest (416.66±24.39 kg). The average of the trait from farm 2 also showed the lowest (244.88±24.73 kg). Dressing percentage from farm 5 showed the highest (57.78±2.79 %), but was not statistically different from farm 1, 8, 12, and 6 (57.33, 57.19, 57.17, and 57.11 %, respectively). The lowest average of the trait was found in farm 2 (51.14±1.42 %). The average carcass length from farm 11 was greater than those from farm 2, 160.55±6.67 cm and 125.34±6.37 cm, respectively.

Table 5. Least squares means and standard errors (LSM±SE) of studied traits affected by farm

Farm source	FLW[1] (kg) LSM±SE	HCW[2] (kg) LSM±SE	DP[3] (%) LSM±SE	CL[4] (cm) LSM±SE
1	616.24±73.19$^{c5/}$	358.76±44.61^{abc}	57.33±2.55^{a}	155.00±11.49^{abcd}
2	484.59±40.58^{c}	244.88±24.73^{c}	51.14±1.42^{b}	125.34±6.37^{d}
3	738.43±46.17^{ab}	409.43±28.14^{ab}	55.36±1.61^{a}	154.46±7.25^{abcd}
4	650.37±57.58^{bc}	348.49±35.10^{bc}	52.83±2.01^{ab}	157.11±9.04^{abc}
5	571.77±80.02^{c}	331.56±48.77^{bc}	57.78±2.79^{a}	120.26±12.56^{d}
6	553.24±73.19^{c}	324.71±44.61^{bc}	57.11±2.55^{a}	154.00±11.49^{abcd}
7	685.44±40.52^{ab}	388.55±24.70^{ab}	56.55±1.41^{a}	151.64±6.36^{abcd}
8	542.90±90.01^{c}	312.63±54.86^{c}	57.19±3.14^{a}	147.51±14.13^{abcd}
9	616.86±33.76^{c}	322.89±20.58^{c}	52.61±1.18^{ab}	143.42±5.30^{cd}
10	652.48±41.09^{abc}	348.79±25.04^{bc}	53.41±1.43^{ab}	142.44±6.45^{cd}
11	749.77±42.48^{a}	395.77±25.89^{ab}	52.28±1.48^{ab}	160.55±6.67^{a}
12	729.24±40.02^{ab}	416.66±24.39^{a}	57.17±1.40^{a}	159.00±6.28^{ab}
13	664.54±39.26^{abc}	365.17±23.93^{abc}	55.04±1.37^{a}	145.81±6.16^{bcd}

[1] Final live weight, [2] Hot carcass weight, [3] Dressing percentage, [4] Carcass length, [5] Means with different superscript letter differ within column (P<0.05)

Effects of slaughter month

The averages of final live weight, hot carcass weight, dressing percentage of slaughtered animals in April were greater than those of the slaughtered animals in March, May and June, especially in May where the averages of final live weight and hot carcass weight showed the lowest, as shown in Table 6. Although the averages of final live weight and hot carcass weight of slaughtered animals in June were lower than those in April, their average dressing percentage did not differ from those in April (57.16±0.96 % in June and 57.76±1.25 % in April, respectively). The lowest of dressing percentage was found in March (50.26±1.98 %). The average of thoracic cavity depth of slaughtered cattle in April, May, and June was greater than those slaughtered in January (49.46±2.35 cm in April, 48.40±1.65 cm in May, 49.22±1.81cm in June, and 39.13±2.34 cm in January, respectively). In contrast to carcass length, the slaughtered animals in January had the longest carcass than those in all months, except those in February. Average skin weight of slaughtered cattle in May was lower than those in February and in April, but not different from those in January, March, and June.

Table 6. Least squares means and standard error (LSM±SE) of studied traits impacted by slaughter month

Traits	Slaughter month (2019)					
	January LSM±SE	**February LSM±SE**	**March LSM±SE**	**April LSM±SE**	**May LSM±SE**	**June LSM±SE**
FLW[1]	662.70±35.75[ab]	677.92±45.20[ab]	598.57±6.67[bc]	701.13±35.89[a]	533.44±25.21[c]	636.65±27.55[b]
HCW[2]	377.70±21.79[ab]	368.11±27.55[ab]	297.98±34.54[bc]	406.94±21.87[a]	291.25±15.37[c]	366.46±16.79[b]
DP[3]	56.53±1.25[ab]	54.08±1.58[bc]	50.26±1.98[c]	57.76±1.25[a]	54.59±0.88[bc]	57.16±0.96[a]
TCD[4]	39.13±2.34[b]	43.14±2.96[ab]	48.29±3.71[ab]	49.46±2.35[a]	48.40±1.65[a]	49.22±1.81[a]
CL[5]	168.67±5.61[a]	163.19±7.09[ab]	128.84±8.89[cd]	145.85±5.63[c]	128.73±3.96[d]	149.28±4.32[bc]
SKW[6]	42.31±3.93[ab]	47.10±4.88[a]	43.89±5.89[ab]	47.43±3.99[a]	33.87±2.62[b]	42.47±3.61[ab]

[1]Final live weight (kg), [2] Hot carcass weight (kg),[3] Dressing percentage (%), [4]Thoracic cavity depth (cm),[5] Carcass length (cm),, [6]Skin weight (kg), [abcd] Means with different superscript letter differ within row (P<0.05)

Relationship study

Relationship of studied traits with thoracic cavity depth and carcass length was shown in Table 7. There were highly significant and positive correlations between final live weight and hot carcass weight, dressing percentage, carcass length, and skin weight (P<0.05 which the correlation coefficients were 0.948, 0.365, 0.508, and 0.635, respectively. The hot carcass weight had significant positive correlation with dressing percentage, carcass length, and skin weight with the correlation coefficients of 0.640, 0.474, and 0.682, respectively. The dressing percentage also had significant positive correlation (r = 0.464) with skin weight (P<0.05. The thoracic cavity depth had negative correlation (R = -0.325) only with carcass length (P<0.05). There was no correlation found between thoracic cavity depth and carcass length with skin weight (P>0.05). However, the percentage of skin weight had negative correlation with carcass length (r = -0.287) but had positive correlation with skin weight in kilograms (r = 0.586).

Table 7. The correlation coefficient between studied traits

Carcass traits	**HCW**	**DP**	**TCD**	**CL**	**SKW**	**PSK[4]**
Final live weight, FLW	0.948**[1]	0.365**	0.213[ns3]	0.508**	0.635**	-0.247[ns]
Hot carcass weight, HCW	1	0.640**	0.180[ns]	0.474**	0.682**	-0.139[ns]
Dressing percentage, DP		1	0.025[ns]	0.146[ns]	0.464**	0.220[ns]
Thoracic cavity depth, TCD			1	-0.325*[2]	0.070[ns]	-0.117[ns]
Carcass length, CL				1	0.192[ns]	-0.287*
Skin weight, SKW					1	0.586**

[1] P<0.01, [2] P<0.05, [3] Not significant difference, [4] Percentage of skin weight

Discussion

Results from the study showed that the minimum final live weight was 427 kg, although the Cooperative requires approximately 500 kg of slaughter weight. This might be concerned that the visual estimation of final live weight from body shape of the cattle at the farm, which expected to be 500 kg, but when the animal was weighed at the slaughter house, it was only 427 kg. The study of Tuntivisoottikul and Limsupavanich (2018) reported that the number of pairs of permanent incisors or cattle age had an impact on hot carcass weight, hot carcass weight percentage, and skin weight. The male dairy cattle with 0-3 pairs of permanent incisors (younger cattle) had greater hot carcass weight, percentage of hot or chilled carcass weight, and skin weight than the female dairy cattle. However, from this study, the results showed that the gender and age of fattened dairy cattle did not have any effect on hot carcass weight, dressing percentage, thoracic cavity depth, carcass length, and skin weight. This might be the distribution of the present data that was quite narrow due to the small sample size (n=59).

Farm is an extrinsic factor where one may differ from another. Optimum nutrition, good management and disease control, and other factors may impact the health and performance of animals. Results indicated that factor of farm can highly significant influenced on its final live weight, hot carcass weight, dressing percentage, and carcass length. It is interested to find that farm 11 showed the highest final live weight (749.77±42.48 kg), and farm 5 and 2 had the lowest of the trait (571.77±80.02 kg for farm 5, and 484.59±40.58 kg for farm 2), the highest dressing percentage in farm 5 (57.78±2.79 %) was found, while the trait in farm 11 and farm 2 averaged of 52.28±1.48 %, and 51.14±1.42 %, respectively. In general, the Cooperative sets criteria that slaughter animal should have the slaughter weight of at least 550 kg and 52% or more of chilled carcass percentage. The percentage of chilled carcass weight is approximately 2 % lower than those of hot carcass weight. The animals had about 49 % chilled carcass weight. It is necessary that farm 2 should consider how to fatten its dairy cattle to obtain more slaughter weight (>550 kg), as well as more dressing percentage.

The cattle study period was observed from January to June. For the average climate months in Thailand, January is the cool season, while summer starts from February to beginning of May. After the third week of May is the rainy season that continues to September. However, because of climate change, this year's El Niño impacted Thailand's summer or dry season, resulting in a longer summer than the previous year (Thairath, 2019). As mentioned above, these might be the reasons that our results showed that all the studied traits were affected by the slaughter month factor, except for the percentage of skin. Another reason is that the Cooperative members

received a quota of 2 to 10 animals per month per farm, depending on farm size, to send to the slaughterhouse. Hence, when the time came, farmers selected their animals with slaughter weight of 500 kg or more by using visual estimation, and then sent them out for slaughtering.

The carcass length had a significantly positive correlation with final live weight (50.8%) and hot carcass weight (47.4%), and had negative correlation with thoracic cavity depth (-32.5%). Higher final live weight and hot carcass weight increased carcass length (longer loin), while longer cavity depth it meant shorter carcass length. It may be useful when this result was applied to create prediction equation to estimate carcass traits, as seen in beef cattle where the body length and heart girth were used to estimate body weight.

With this, results indicated that the factors of farm and slaughter month had more impact on the carcass traits of fattened dairy cattle than biological factors, gender and age. It is preliminary studied on the relationship of the carcass traits with the carcass length and thoracic cavity depth, other morphometric measurements with carcass and meat characteristics in fattened dairy cattle in Thailand. It should be further studied for the characteristics that could be better predicted.

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References

Assan, N. (2013). Bioprediction of body weight and carcass parameters from morphometric measurements in livestock and poultry. Scientific Journal of Review, 2:140-150.

Coopman, F. (2008). Morphometric assessments in the double-muscled Belgian Blue beef breed. Retrieved from https://www.researchgate.net/publication/ 294262990.

Guerrero, A., Valero, M. V., Campo, M. M. and Sañudo, C. (2013). Some factors that affect ruminant meat quality: from the farm to the fork. Review. 2013. Acta Scientiarum. Retrieved from Doi:10.4025/actascianimsci.v35i4.21756.

Orts, F. A. (1959). The relationship of the long bones of the thoracic and pelvic limbs as an indicator of muscling in the beef animal. Reciprocal Meat Conference Proceedings, Columbia, MO, 125 p.

SAS (1999). SAS/STAT User's Guide: Statistic, SAS Institute Inc. North Carolina.

Sethakul, J. (2016). Fattening dairy beef: the opportunity to entering in market quality beef. In Seminar of Fattening Dairy Beef: Opportunity and Preparedness in Beef Shortage Crisis. Meajo University, Chiang Mai, pp. 1-7.

Taylor, R. E. (1984). Beef Production and the Beef Industry. Macmillan Publishing. New York, New York.

Thairath (2019). El Niño: Keep up with drought in rainny season. Retrieved from https://www.thairath.co.th/news/local/bangkok/ 1539138.

Torrescano Urrutia, G. R., Sánchez Escalante, A., Palmab, V., Gustavo, M., Pellat, R. P. and Pardo Guzmán, D. A. (2010) Characterization of bovine carcasses and meat

from animals fattened in Central Sonora. Revista Mexicana de Ciencias Pecuarias, 1:157-168.
Tuntivisoottikul, K. and Limsupavanich, R. (2018). Effects of gender of dairy or beef cattle and the number of pair of permanent incisors on carcass traits. MATEC Web of Conferences, 192, 03050.

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