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Effect of sex, age and final live mass on carcass traits of fattening dairy cattle

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Abstract Most animals (63.25 %) obtained a marbling score of 2 while 19.27 % obtained a score of 1. Marbling score was not affected by all the studied factors (P>0.05). Sex had a significantly stronger effect on hot and chilled carcass mass (P<0.01): averages for both hot and chilled carcass masses of males were greater than those of females. All studied traits (P<0.05), except chilling loss (P>0.05), were influenced by age. Averages of both hot and chilled carcass mass, both in kg and in proportion of animals with 3 yrs age were higher, but not statistically different from those of 4 yrs animals. Most traits were significantly affected by final live mass (P<0.01). As the final live mass increased, both hot and chilled carcass mass in kg and as a fraction increased, and chilling loss both in kg and as a fraction decreased.

Keywords: Carcass traits, Fattening dairy cattle, Thailand

Introduction

The number of beef cattle in Thailand is decreasing due to an increase in agro-industries. Instead of forage crop planting, the land is now being used to grow sugar cane, cassava, pineapple, para rubber and others. Thus, there is insufficient beef for consumption, therefore dairy beef has become an alternative to solve the problem. Holstein Friesian (Black and White) is a popular dairy breed. Heifers and cows are culled from herds for several reasons, such as failure in reproduction, illness, mastitis, decreased milk yield, etc. They are then intensively fed for beef production. Male dairy calves are not needed for milk production, so they are fed as growing and finishing dairy beef cattle. At present, about 20% of beef in the market comes from these dairy cattle (Sethakul, 2016) not only in Thailand but many countries also feed dairy cattle for beef (Barton *et al*., 1997; Liinamo, 2000; Wardynski, 2012; Bazzoli *et al*., 2013; Ardicli *et al*., 2018). In general, meat from dairy cattle has a lower price than that of beef cattle, because dairy cattle are light muscled and have different ribeye shape (Ledbetter, 2018). The intramuscular fat or marbling is an

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important criterion aside from chilled carcass mass for pricing. A higher marbling score increases the price. However, few studies of dairy beef cattle in Thailand exist, especially regarding carcass characteristics. Thus, studying about intrinsic factors such as sex, age, and final live mass influence on carcass traits of fattened dairy cattle would be useful for both beef and dairy cattle farmers.

Materials and methods

167 Dairy (at least 75% Holstein Friesian) cattle, both male and female (culled heifers and cows) reared by members of Beef Cluster Cooperative Ltd, were sampled. Male calves were given feed concentrate, with 20 to 22 % crude protein at 15 days old. The animals were weaned when their body mass was more than 50 kg and they they were given feed concentrate of at least 500 g per day for at least 7 days. They were castrated when their body mass was about 200 kg. During the first growing period (10 to 15 months old), they were fed with 16 % crude protein concentrate at about 3 kg per day and fresh grass until their body mass was 200 to 300 kg. In the second growing period (16 to 20 months old), they were fed with 15 % crude protein concentrate at 4 kg per day until they reached 300 to 400 kg body mass. After that, the finishing or fattening period started, they received TMR (Total Mixed Ration) with 12 % crude protein *ad libitum* until their body mass reached 600 kg (Sawanon, 2012). Fattening period was about 8 to 10 months. For females (heifers and cows), after they were culled, they were intensively fattened with 14 % crude protein concentrate and supplied with fresh grass, or by products from agro-industries, such as pineapple peel, baby corn bark, fermented cassava, etc. Some farms fed their animals with TMR feed. Most were fattened for 4 to 8 months until they reached at least 500 kg. Then both male and female were transported to slaughterhouses. There, they were given drinking water *ad libitum* with fasting for 10 to 12 h. The final live or slaughter mass was determined and recorded before slaughter.

Data from January to May 2019 was collected from two sources. The first came from the farm for farm and animal identifications, sex and slaughter date. The second came from the slaughterhouse for age, final live mass, hot carcass mass and chilled carcass mass. Age was estimated by counting the pairs of permanent incisors; 1st pair - 1½ to 2 years old, 2nd pair - 2½ to 3 years old, 3rd pair - 3½ to 4 years old, and 4th pair - 4½ to 5 years old or older than 5 years (Taylor, 1984). The animals were slaughtered at a private commercial slaughterhouse, in Rachaburi Province, Thailand. After stunning, bleeding, removing of head, skin, legs, and evisceration, the carcass was cleaned and split

into halves, then both sides of the carcass were weighed as hot carcass mass. The carcass was chilled at 2 to 4°C for 7 days. After that it was weighed again, as cold carcass or chilled carcass mass, then it was dissected between the 12th and 13th rib for intramascular fat estimation. Marbling was scored on a five points scale, where 1=devoid; 2=slight; 3=small; 4=moderate; 5=abundant; following the TACFS 6001-2004 Standard (ACFS, 2004). Hot carcass mass fraction was calculated from hot carcass mass divided by final live mass multiplied by 100. Similarly, chilled carcass mass fraction divided by final live mass, multiplied by 100. Chilling loss calculated from hot carcass minus chilled carcass mass, and the chilling loss was computed based on hot carcass mass.

Descriptive statistics - mode (marbling score), mean, standard deviation, minimum, and maximum - were used to analyse the data. Mode of marbling score was 2. Although the highest point on the marbling score was 5, the highest observed score was 4. Final live mass ranged from 427 to 840 kg. Hot carcass mass ranged from 232.70 to 483.30 kg and chilled carcass mass ranged from 226.10 to 473.00 kg. The average fractions of hot and chilled carcass masses were 54.04 and 52.40 %, respectively. The average chilling loss was 10.16 kg and chilling loss in fraction was 3.04 %, respectively (table 1).

Table 1. Means, standard deviations and ranges (N=167)

Carcass traits	Mean	Std Dev	Minimum	Maximum
Marbling score[1]/	2[2]/	-	1	4
Final live mass (kg)	622.15	74.53	427.00	840.00
Hot carcass mass (kg)	336.76	47.97	232.70	483.30
Chilled carcass mass (kg)	326.60	47.25	226.10	473.00
Hot carcass mass (%)	54.04	2.75	48.38	61.01
Chilled carcass mass (%)	52.40	2.77	47.11	59.29
Chilling loss (kg)	10.16	1.76	6.30	16.20
Chilling loss (%)	3.04	0.52	2.03	4.48

1/: N=162
2/: Mode

Because the marbling score was definded as ordinal scale, frequency and χ^2 tests were used to analyse sex and age factors, which were estimated from pairs of permanent incisors and final live mass groups affecting the trait. The others traits, such as hot carcass mass, chilled carcass mass, fractions of hot carcass mass, chilled carcass mass, chilling loss mass and chilling loss fraction were analyzed with a general linear model:

$$Y_{ijkl} = \mu + S_i + A_j + FLWG_k + e_{ijkl}$$

where: Y_{ijkl} is the studied trait of observed animals; μ is overall mean; S_i is fixed effect of sex of animal ith (i=1, 2, when 1=male, 2=female), A_j is fixed effect of pair of permanent incisors jth (j = 1, 2, 3, 4, when 1 to 4 were 1= 2 yrs

old, 2= 3 yrs old, 3= 4 yrs old, and 4= 5 yrs old or older); $FLWG_k$ is fixed effect of group of final live mass k^{th} (k= 1, 2, 3, when 1=<550 kg, 2=550 to 650 kg, and 3=>650 kg; e_{ijkl} is random effect of residual. If there was significant variance in F test, differences of the LS-means would be displayed by using the pdiff option (SAS, 1999).

Results

Factors that affected the studied traits

Analysis of marbling score showed that it was not affected by sex, age, and final live mass (P>0.025) – see Table 2. Sex significantly influenced hot and chilled carcass masses (P<0.01) - see Table 3. Age significantly affected all traits (P<0.05), except chilling loss (P>0.05). Almost all studied traits were significantly affected by final live mass (P<0.01).

Table 2. χ^2 tests for marbling score *vs* sex, age, and final live mass

Factors	Tests	χ^2	df	Asymptotic Significance (2-sided)
Sex	Pearson Chi-Square	.351[a]	3	.950
	Likelihood Ratio	.350	3	.950
	[a.]2 cells (25.0%) had expected counts less than 5. The minimum expected count was 1.27.			
Age	Pearson Chi-Square	12.179[a]	9	.203
	Likelihood Ratio	11.967	9	.215
	[a.]11 cells (68.8%) had expected counts less than 5. The minimum expected count was .15.			
Final live mass group	Pearson Chi-Square	5.627	6	.466
	Likelihood Ratio	5.794	6	.447
	[a.] 4 cells (33.3%) had expected counts less than 5. The minimum expected count was .86.			

Table 3. P-values and R^2 for factors affecting carcass traits

Carcass traits	P-values			R^2
	Sex	Age	FLWG[1/]	
Hot carcass mass (kg)	0.0080	0.0550	<.0001	0.7498
Chilled carcass mass (kg)	0.0100	0.0414	<.0001	0.7494
Hot carcass mass (%)	0.1363	0.0317	0.0006	0.1683
Chilled carcass mass (%)	0.1627	0.0195	0.0001	0.1856
Chilling loss (kg)	0.1150	0.2612	<.0001	0.1609
Chilling loss (%)	0.6420	0.0200	<.0001	0.1676

1/: Final live mass group

Effect of sex

Although the studied factor did not influence marbling score, about 48.1% of female and 15.4% of male carcasses obtained a marbling score of 2 (Table 4). About 2.5% of females had marbling score of 4, while 0.6% of male obtained that score. It was interesting to see that most carcasses had scored 2.

Table 4. Marbling score *vs* sex of animal

Factor	Category		Marbling score				Total
			1	2	3	4	
Sex	Female	Count	22	78	17	4	121
		% of Total	13.6%	48.1%	10.5%	2.5%	74.7%
	Male	Count	8	25	7	1	41
		% of Total	4.9%	15.4%	4.3%	0.6%	25.3%
Total		Count	30	103	24	5	162
		% of Total	18.5%	63.6%	14.8%	3.1%	100%

Averages hot and chilled carcass masses of male cattle were significantly greater than those of females (339.10±4.21 kg and 328.96±4.15 kg for hot and chilled carcass masses of males, and 324.70±4.73 kg and 315.14±4.66 kg for females, respectively) - see Table 5.

Table 5. Least squares means and standard error of carcass traits vs sex of animals

Carcass traits	Sex	
	Female	Male
	LSM±SE	LSM±SE
Hot carcass mass (kg)	$324.70 \pm 4.73^{b1/}$	339.10 ± 4.21^{a}
Chilled carcass mass (kg)	315.14 ± 4.66^{b}	328.96 ± 4.15^{a}
Hot carcass mass (%)	53.78 ± 0.49^{a}	54.62 ± 0.44^{a}
Chilled carcass mass (%)	52.18 ± 0.49^{a}	52.97 ± 0.44^{a}
Chilling loss (kg)	9.56 ± 0.32^{a}	10.13 ± 0.28^{a}
Chilling loss (%)	2.98 ± 0.09^{a}	3.03 ± 0.08^{a}

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

Effect of age

About 74.7% of animals were ≥ 5 yrs old, but only 1.9% received marbling score 4. Furthermore, 1.2 % of 4 yr old animals obtained the same score. No younger animals received this score, as shown in Table 6.

Table 6. Frequency of marbling scores vs age of animals

Factor	Category		Marbling score				Total
			1	2	3	4	
Age (yrs old)	2	Count	1	3	1	0	5
		% of Total	0.6%	1.9%	0.6%	0.0%	3.1%
	3	Count	1	13	1	0	15
		% of Total	0.6%	8.0%	0.6%	0.0%	9.3%
	4	Count	5	8	6	2	21
		% of Total	3.1%	4.9%	3.7%	1.2%	13.0%
	≥ 5	Count	23	79	16	3	121
		% of Total	14.2%	48.8%	9.9%	1.9%	74.7%
Total		Count	30	103	24	5	162
		% of Total	18.5%	63.6%	14.8%	3.1%	100%

Average hot and chilled carcass masses of 3 yr old animals were the highest, but did not significantly differ from those of 4 yr old animals, as shown in Table 7. A similar result as mentioned above was found in fractions of hot and chilled carcass masses. The oldest animals (≥5 yrs age) showed the highest chilling loss in fraction, but it was not significantly different from 2 yr old animals.

Table 7. Least squares means and standard errors of carcass traits *vs* age of animals

Traits	Age			
	2 yr old LSM±SE	3 yr old LSM±SE	4 yr old LSM±SE	≥ 5 yr old LSM±SE
Hot carcass mass (kg)	319.12±11.30$^{b1/}$	343.09±6.45^{a}	337.79±5.33^{ab}	327.59±3.16^{b}
Chilled carcass mass (kg)	309.42±11.14^{b}	333.83±6.36^{a}	327.59±5.25^{ab}	317.37±3.12^{b}
Hot carcass mass (%)	52.48±1.18^{b}	55.53±0.67^{a}	54.91±0.56^{ab}	53.89±0.33^{b}
Chilled carcass mass (%)	50.84±1.18^{b}	54.03±0.67^{a}	53.24±0.56^{ab}	52.20±0.33^{b}
Chilling loss (kg)	9.70±0.76^{a}	9.26±0.43^{a}	10.20±0.36^{a}	10.22±0.21^{a}
Chilling loss (%)	3.12±0.22^{ab}	2.70±0.13^{b}	3.06±0.11^{b}	3.16±0.06^{a}

1/: Different superscript letters indicate significantly different values within each row.

Effect of final live mass

Although the marbling score was not affected by final live mass (Table 8) most animals (43.8%) had final live mass in the 550 to 650 kg group while 17.3% were <550 kg. About 0.6% of the animals in the group of the highest and the lowest final live mass obtained marbling score of 4, while 1.9% of them with 550 to 650 kg live mass scored the same.

Table 8. Marbling score vs final live mass

Factors	Category		Marbling score				Total
			1	2	3	4	
Final live mass (kg)	<550	Count	8	15	4	1	28
		% of Total	4.9%	9.3 %	2.5%	0.6%	17.3%
	550-650	Count	8	49	11	3	71
		% of Total	4.9%	30.2%	6.8%	1.9%	43.8%
	>650	Count	14	39	9	1	63
		% of Total	8.6%	24.1%	5.6%	0.6%	38.9%
Total		Count	30	103	24	5	162
		% of Total	18.5%	63.6%	14.8%	3.1%	100.0%

The final live mass influenced all traits. Table 9 shows that the highest averages of hot carcass mass (389.19±4.41 kg) and chilled carcass mass (378.52±4.34 kg), and the highest of fractions of hot carcass mass (55.33±0.46 %) and chilled carcass mass (53.81±0.46 %) were found in animals with mass more than 650 kg. Chilling loss of animals with live mass less than 550 kg was the lowest (8.98±0.36 kg) and those with live mass more than 650 kg was the highest (10.66±0.30 kg). In contrast to the fraction of chilling loss, it found that animals with live mass heavier than 650 kg had the lowest chilling loss (2.74±0.09 %).

Table 9. Least squares means and standard error for carcass traits affected by final live mass

Traits	Final live mass (kg)		
	<550	550-650	>650
Hot carcass mass (kg)	280.99±5.42$^{c1/}$	325.51±3.96^{b}	389.19±4.41^{a}
Chilled carcass mass (kg)	272.01±5.35^{c}	315.62±3.91^{b}	378.52±4.34^{a}
Hot carcass mass (%)	53.52±0.57^{b}	53.77±0.41^{b}	55.33±0.46^{a}
Chilled carcass mass (%)	51.79±0.57^{b}	52.13±0.41^{b}	53.81±0.46^{a}
Chilling loss (kg)	8.98±0.36^{c}	9.89±0.27^{b}	10.66±0.30^{a}
Chilling loss (%)	3.23±0.11^{a}	3.06±0.08^{a}	2.74±0.09^{b}

1/: Different superscript letters indicate significantly different values within each row.

Discussion

We found that sex, age, and final live mass did not influence marbling scores (P>0.025). Although age and final live mass did not affect marbling score, we note that 9.9% and 1.9% of animals with age ≥5 yrs obtained

marbling score of 3 and 4, respectively, and 6.8 and 1.9 % of animals in the 550-650 kg group obtained scores of 3 and 4. Supphakitchanon *et al.* (2015) reported that marbling score increased in animals which were 4 yrs or older, and culled dairy cows >651 kg had higher marbling scores than others (P>0.01). Furthermore, they also found that 38.71, 41.01, 17.97 and 2.30% of culled dairy cows obtained marbling scores of 1 to 4, which is similar to our results: 18.5, 63.6, 14.8, and 3.1% for scores 1 to 4, respectively. Our results agree with those of Supphakitchanon *et al.* (2015) and Tuntivisoottikul and Limsupavanich (2018) that most carcasses obtained scores of 2. However, we saw no carcasses with marbling score 5, consistent with Supphakitchanon *et al.*, whereas Tuntivisoottikul and Limsupavanich found that highest marbling score 5 was in female dairy cattle with 4 pairs of permanent incisors. This may simply be the smaller sample size (162 heads) of our study relative to the 571 heads in the previous study.

Male dairy cattle had on average both hot and chilled carcass masses greater than those of females, but the hot:chilled ratios did not differ. Male cattle were raised more intensively with a longer fattening period, than females (heifers and cows). Chainam and Opatpatanakit (2016) also reported that the average hot and chilled carcass masses of dairy steers were higher than those of dairy cows.

The higest average hot and chilled carcass masses, both in kilogram and in percentage, were found in the 3 yr old cattle, but this did not differ significantly from 4 yr olds. The average traits in the youngest and the oldest animals were lower than those in the 3 yr old animals, but also did not differ significantly from 4 yr olds. The muscle in the youngest was still developing, while the oldest had deposited fat. Tuntivisoottikul and Limsupavanich (2018) reported similar results for hot and chilled carcass masses and percentage of chilled carcass masses for 3 yr old dairy cattle (2^{nd} pair of permanent incisors) - averages of these traits higher than the others, but similar to 4 yr olds (3^{rd} pair of permanent incisors).

Our study showed that, as final live mass increased, both hot and chilled carcass mass in kg and as a fraction increased, and chilling loss both in kg and as a fraction decreased. These results agreed with Chainam and Opatpatanakit (2016).

To raise dairy cattle for beef production, farmers should consider two criteria, highest chilled carcass mass and marbling score so that they will achieve a higher return, but as a buyer, the cooperative needs more than 52 % chilled carcass mass. Hence, this study suggests that farmers should fatten their dairy cattle for 3 or 4 yrs and achieve a final live mass of more than 650 kg.

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