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The influence of fattening periods on performance, carcass composition, and meat quality of Charolaise crossbred steers

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Abstract Results showed that the initial weight did not differ between groups (P>0.05). While, the 15 month group had more heavy weight than 12 month group (P<0.01). Furthermore, the 15 month group gained more weight than 12 month group (P<0.05). The average daily gain of 15 month group was higher than 12 month group (P<0.01) which were 723.62 and 603.30 gram/day, respectively. The weight of hot and cold carcass of 15 month group was higher than 12 month group (P<0.01) while the percentage of hot and cold carcass did not differ between group (P>0.05). For carcass composition, lean percentage (P<0.01) and bone percentage (P<0.05) were higher in 15 month group than in 12 month. Meat color, shrinkage loss, cooking loss, and shear force did not affect by fattening period (P>0.05). In addition the fattening period did not impact on collagen content and also collagen solubility (P>0.05).

Keywords: Charolais crossbred steers, Fattening period, Performance, Carcass composition, Meat quality

Introduction

The beef cattle markets in Thailand is separated on the price and quality of beef. There are three beef markets; tradition, mid-value, and premium. The premium or high quality beef has market share only 1% (Skunmun, 2014). For producing premium beef, cattle are fed for 8 to 12 months with a high energy

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diet with low fiber content. Also high quality beef with high intramuscular fat content is produced in fattening farms and sold in supermarkets. The carcass is chilled and aged for 2 weeks to improve tenderness. Regarding the improving of economics status, people tend to consume more meat as protein source. Which provides opportunities for beef cattle farmers to increase beef production not only the quantity but also the quality to meet the consumer demand. Bunmee *et al.* (2018) stated that higher growth performance and meat quality are affected by breed, nutrition, and management. Therefore the several *Bos taurus* are imported for using as the terminal sires to cross with native or other *Bos indicus* breeds. The major terminal sire breeds for producing high quality crossbred beef cattle in Thailand are Charolais (Bureau of Biotechnology in Livestock Production, 2018).

Charolais breed has high average daily gain and high muscularity compared to other breeds (Shackelford *et al*., 1994; Holló *et al*., 2012; Gallo *et al*., 2014). The most common beef breed used for terminal crossing with *Bos indicus* such as Thai native breed and Brahman for commercial beef production in Thailand is Charolais (Bureau of Biotechnology in Livestock Production, 2018). The growth performance of Thai native and Brahman beef cattle can be improved by being crossed with Charolais purebred (Waritthitham *et al.*, 2010).

Normally the fattening period for producing high quality beef is 12 months however the beef producers still faced the problem of beef quality variation especially insufficient marbling level. The standard for high quality beef from the largest high quality beef production in Thailand, Pon Yang Kham Livestock Breeding Cooperative, the marbling score should be higher than 3.5 scores. The hypothesis of this study was to increase fattening period to be longer than 12 months and marbling score. Therefore, the objective of this study was to compare the effect of fattening period for 12 or 15 months on growth performance, carcass characteristics, and meat quality.

Materials and methods

Animals and feeding

The study was conducted at a Pon Yang Kham Livestock Breeding Cooperatives Ltd. in Sakon Nakhon Province, Thailand. The animals in this study were 12 offsprings from Brahman purebred or Brahman x Native dams inseminated with frozen semen from the same Charolais sire. Crossbred bulls were castrated by using burdizzo before fattening period start. At the first day of fattening period, the live weight was estimated by

measuring chest girth and the average weight was approximately 380 kg. The 6 steers were fattened for 12 months and the rest were fattened for 15 months. They were raised under the same housing and feeding condition in the cooperative farm in Sakon Nakhon Province. The cattle were fed with concentrate (Table 1), grass, and straw with molasses supplemented after 6 months of fattening period. All steers were weighted and calculated for Average Daily Gain (ADG) from each fattened group before slaughter.

Table 1. Chemical composition of concentrate (as fed)

Nutrients (%)	**Mean±SD**
Moisture	9.28±0.10
Crude protein	12.81±0.86
Crude fiber	9.39±0.24
Crude fat	3.19±0.05
Crude ash	9.34±0.05
Calcium	1.71±0.02
Phosphorus	0.38±0.03
Calcium : Phosphorus	4.5

SD = Standard deviation.

Growth performance traits

Each animal was weighed at the month 8 of fattening period and every month until the end of fattening period, Weight gain was calculated by final weight minus initial weight. Average daily gain (ADG) is the amount weight gain per day for the animal gained over a given period of time.

Carcass traits

When the animals reached the end of fattening period, they were taken to the slaughter house located in the cooperative. They were fasted for 24 h. The animals were weighed (final weight), and then slaughtered. The carcass was spited into 2 halves, left and right sides, and was weight as hot carcass weight. Carcass length on the right side was measured (Domingo *et al.*, 2014). The halves of carcasses were chilled at 4℃ for 7 days. On the 7^{th} day, they were quartering into fore and hind quarters at 12^{th}-13^{th} ribs. All carcasses were weighed as cold carcass weight. The percentage of the hot carcass and that of the cold carcass were calculated by using the hot or cold carcass weight divided with final weight and multiplied with 100. Percentage of chilling loss was calculated by using hot carcass weight minus cold carcass weight, then divided with hot carcass weight and multiplied with 100.

Carcass compositions

The fore and hide quarters of the left side of carcass were dressed following the cooperative procedure. The deboned and each trimmed cut were weighed. The weight of lean, bone, fat, and tendon in kg. were collected and then were calculated to be percentages.

Measurement of meat quality

Shrinkage loss

After ageing, *Longissimus dorsi* (LD) steaks cut to a thickness of 1 inch were weighed and chilled with a temperature of 1-4 C for over night and then put tissue paper on top of meat sample for absorbing water out of surface area. After taking surface water out, LD steaks were weighted again. Shrinkage loss percentage was estimated by calculating the difference between before and after chilling for over night.

Color

For color measurement, the LD was allowed to bloom for 30 min before measuring CIE L*, a*, and b* color values using a Chroma Meter (CR-400, Minolta Co., Ltd., Suita-shi, Osaka, Japan).

Cooking loss and shear force

Cooking loss and shear force measurement, two pieces of approximately 3-cm-thick slice obtained from LD were weighed, placed into high density polyethylene bag, heat sealed, and then cooked in water bath set at 80 ℃ for 30 min or until internal temperature of meat sample reached 70 ℃. After cooked, samples were cooled down by running tap water to room temperature before weighing then cooking loss percentage was estimated by calculating the difference between before and after cooking weight. Ten 1x2x1 cm^3 cut in each cooking loss sample were removed from across the slice parallel to the muscle fiber orientation. Each cutting was sheared once perpendicular to the muscle fiber orientation using a Warner-Bratzler shear head attached to a single column Texture Analyzer Machine (Model EZSX, Shimadzu, Japan) equipped with a 50 kg. load cell using 50 mm/min crosshead speed.

Collagen content

Soluble, insoluble, and total collagen were determined by the method of Hill (1966). The 0.9 g. of the minced meat sample was added with 3 ml of ¼ strength Ringer's solution. The mixture was homogenized with a polytron

(T20, Ika, Switzerland) and the probe was rinsed with 2 ml of ¼ strength Ringer's solution to collect residues. The homogenate was incubated at 77℃ for 60 min then centrifuged at 2,500 x g for 10 min. The supernatant was adjusted to 6 - 7 pH with 6 M sodium hydroxide, filtered through filter paper no.1 (Whatman), and diluted with distilled water to either 100 or 500 ml for soluble and insoluble assay, respectively. To determine the hydroxyproline concentration, the 400 µl of the diluted hydrolysate was added with 200 µl of freshly prepared Chloramine T hydrate (Cas no.149358-73-6, Sigma-Aldrich) in an aqueous buffer solution (pH 6.0) which contained NaOH, citric acid, sodium acetate and 1-propanol and incubated at room temperature for 20 min. Then 200 µl of 4-dimethylamino-benzaldehyde reagent (Ehrlich's reagent, Sigma-Aldrich) in an aqueous solution containing strong (70 %) perchloric acid and 2-propanol was added and incubated at 60 ℃ for 20 min then at 25 ℃ for 20 min. Absorbance at 550 nm was measured with a microplate reader (Tecan, UK). Hydroxyproline content was determined using a standard curve for hydroxyproline (Cas no.51-35-4, Sigma-Aldrich) with the collagen content being calculated from the hydroxyproline content using a conversion factor of 7.25.

Statistical analysis

The independent t-test was used to compare growth performance, carcass characteristics, meat quality, and collagen content between steers fattened for 12 and 15 months using SPSS version 17.

Results

The means and standard deviations of growth performance of steers fattened for 12 and 15 months and P-value were shown in Table 2. It was found that steers fattened for 12 and 15 months had significant differences in final weight, weight gain, and ADG ($P<0.05$). The 15 month group had heavier final weight than 12 month group ($P<0.01$). Furthermore, the 15 month group gained more weight than 12 month group ($P<0.05$). The average daily gain of 15 month group was higher than 12 month group ($P<0.01$), 723.62 and 603.30 g/d, respectively. The hot and cold carcass weight of 15 month group were higher than 12 month group ($P<0.01$) while the percentage of hot and cold carcass were not different between groups (Table 3). For carcass composition, lean percentage ($P<0.01$) and bone percentage ($P<0.05$) were higher in 15 month group than in 12 month group but fat percentage was not significant different ($P>0.05$).

Table 2. Effect of fattening period on growth performance of Charolais crossbred steers

Traits	Fattening period		P-value
	12 months	15 months	
	n = 6	n = 6	
	$(\bar{X} \pm SD)$	$(\bar{X} \pm SD)$	
Initial weight (kg)	384.33±41.85	390.00±10.95	0.755
Final weight (kg)	604.34±58.73[a]	724.49±4.51[b]	0.003
Weight gains (kg)	220.01±82.64[a]	334.49±44.24[b]	0.014
Average daily gain (g/day)	603.30±58.74[a]	723.62±4.51[b]	0.003

[a,b] Means in rows with different superscripts are significant different at $p < 0.05$.

Table 3. Effect of fattening period on carcass composition of Charolais crossbred steers

Traits	Fattening period		P-value
	12 months	15 months	
	n = 6	n = 6	
	$(\bar{X} \pm SD)$	$(\bar{X} \pm SD)$	
hot carcass weight (kg)	324.17±26.87[b]	324.17±26.87[b]	0.001
hot carcass (%)	55.66±1.30	56.00±1.92	0.726
cold carcass weight (kg)	318.00±27.03 [b]	382.00±29.11 [a]	0.003
chill carcass (%)	54.60±1.21	54.55±1.60	0.935
lean (%)	103.72±8.17[b]	122.33±10.78[a]	0.007
fat (%)	26.90±4.47	28.57±2.37	0.438
bone (%)	24.60±7.47[b]	34.55±6.22[a]	0.031

[a,b] Means in rows with different superscripts are significant different at $p < 0.05$.

Table 4. Effect of fattening period on meat quality of Charolais crossbred steers

Traits	Fattening period		P-value
	12 months	15 months	
	n = 6	n = 6	
	$(\bar{X} \pm SD)$	$(\bar{X} \pm SD)$	
Color			
L*	42.39±3.24	40.58±3.84	0.398
a*	23.14±0.87	22.18±2.23	0.350
b*	13.61±0.81	12.52±0.89	0.050
Shrinkage loss (%)	1.83±0.74	1.59±0.86	0.617
Cooking loss (%)	23.61±3.58	23.17±2.12	0.859
Shear force (kg)	6.01±1.15	5.96±1.81	0.955

Meat color, shrinkage loss, cooking loss, and shear force did not affect by fattening period (P>0.05) as in Table 4. In addition the fattening period did not impact on collagen content and also collagen solubility (P>0.05) as in Table 5.

Table 5. Effect of fattening period on collagen content of Charolais crossbred steers

Traits	Fattening period		P-value
	12 months	15 months	
	n = 6	n = 6	
	$(\bar{X} \pm SD)$	$(\bar{X} \pm SD)$	
Soluble collagen (mg/g)	0.18±0.07	0.27±0.16	0.536
Insoluble collagen (mg/g)	2.57±0.75	2.08±0.89	0.355
Total collagen (mg/g)	2.75±0.81	2.22±0.86	0.346
% collagen solubility	6.32±0.90	6.27±1.62	0.957

Discussion

This study demonstrated that steers fattened for 12 and 15 months had significant difference in final weight, weight gain, and ADG. The 15 month group had heavier final weight and gained more weight than 12 month group. The average daily gain of 15 month group was higher than 12 month group. These results were in agreement with Bures and Barton, (2012) who reported bull and heifer slaughtered at 18 months of age had heavier final

weight than those slaughtered at 14 months of age. However, the ADG from their study was not different while in the present study the longer fattening period showed the higher ADG.

The hot and cold carcass weights of 15 month group were higher than 12 month group. While the percentage of hot and cold carcass weights were not different between groups which were similar to Bures and Barton (2012) results. For carcass composition, lean and bone percentage were higher in 15 month group than in 12 month group but fat percentage was not significant different. Conversely, Nogalski *et al.* (2018) reported that bulls and steers slaughtered at 18 months of age had higher fat percentage and less bone percentage than those slaughtered at 15 months of age. The difference results from the present study may be due to breed different as Nagolski *et al*. (2018) used Charolais x Holstein friesian (50 % Charolais crossbreds) while this study used at least more than 62.5 % Charolais crossbred steers. The heavier final weight and higher ADG of 15 month group indicated that these animals did not reach maturity yet. The development of muscle and fat tissues during growth and maturation in animals as stated in Baker and Mikesell (1996), when the animals get older and larger the muscle growth nearly stops while fat development continues. Therefore, the 15 month group showed higher lean and bone percentage without difference in fat percentage than 12 month group.

Meat quality in terms of meat color, shrinkage loss, cooking loss, and shear force in this study did not affect by fattening period which different from Kopuzlu *et al.* (2018) said that meat colors were affected by slaughter age, older animals had higher L* and a* values than those of younger animals. The shear force value decreased as the slaughter age of animal increased. This situation is expressed by the fact that the meat is tougher due to insufficient muscle fattening by young animals. Also Bures and Barton (2012) stated that the meat lightness was affected by slaughtering age of animals. The color of meat became darker when slaughter age increased. In addition the fattening period did not impact on collagen content and also collagen solubility. Bures and Barton (2012) stated that older animals showed higher concentration of collagen. However, Jurie *et al.* (2005) reported that total collagen content in young bulls remain unchanged between 15 and 19 months of age.

It concluded that the fattening period for 12 or 15 months affected growth performance and carcass characteristics but not meat quality in Charolais crossbred steers. The longer fattening period the higher weight gain, ADG, hot and cold carcass weight, lean and bone percentage were found.

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