Materials and methods

2.1 Animals and feeding

The study was conducted on a commercial beef production company in Chiang Mai, Northern Thailand (Figure 2.1). The experiment included 34 Brahman × Thai native and 34 Charolais × Thai native crossbred bulls (Figure 2.2 and 2.3) which were progenies of Brahman × Thai native or Charolais × Thai native cows sired by Brahman or Charolais, respectively. Percentage of Brahman and Charolais blood, respectively, ranged between 75 to 87.5 % (F2 and F3). Mean age of both genotypes at start of fattening was 19 months and at slaughter was 29 months. Mean live weight at start of fattening was 323 kg (SD = 29.7 kg) and 316 kg (SD = 35.1 kg) for BRA and CHA, respectively. The bulls were housed in a stanchion barn with free access to fresh water and fed *ad libitum* with roughage, mainly seasonal grass, rice straw, corn (fresh and silage) and by-products from the agro-industry. Furthermore, they received 1 kg commercial concentrate diet per 100 kg live weight per day. Chemical analyses of the feed were carried out according to AOAC (1997), van Soest (1963) and van Soest and Wine (1967) (Table 2.1). The animals of both genotypes were randomly selected and slaughtered at a mean live weight of 500, 550, and 600 kg, respectively. The experimental design was 2 (genotype) × 3 (slaughter weight) factorial, resulting in 6 groups with 11 or 12 animals per group.

Table 2.1: Chemical composition of cattle feed

Feed	DM (%)	CP (% DM)	EE (% DM)	Ash (% DM)	NDF (% DM)	ADF (% DM)
Seasonal grass	23.2	13.4	2.59	10.7	58.6	33.4
Corn (whole)	23.5	6.24	1.83	7.08	51.0	31.2
Corn residue (husk and cob)	22.2	5.25	1.67	2.61	68.8	34.0
Rice straw	91.9	4.24	2.25	13.6	65.6	51.6
Commercial concentrate diet	89.9	13.3	2.26	10.1	27.3	19.9

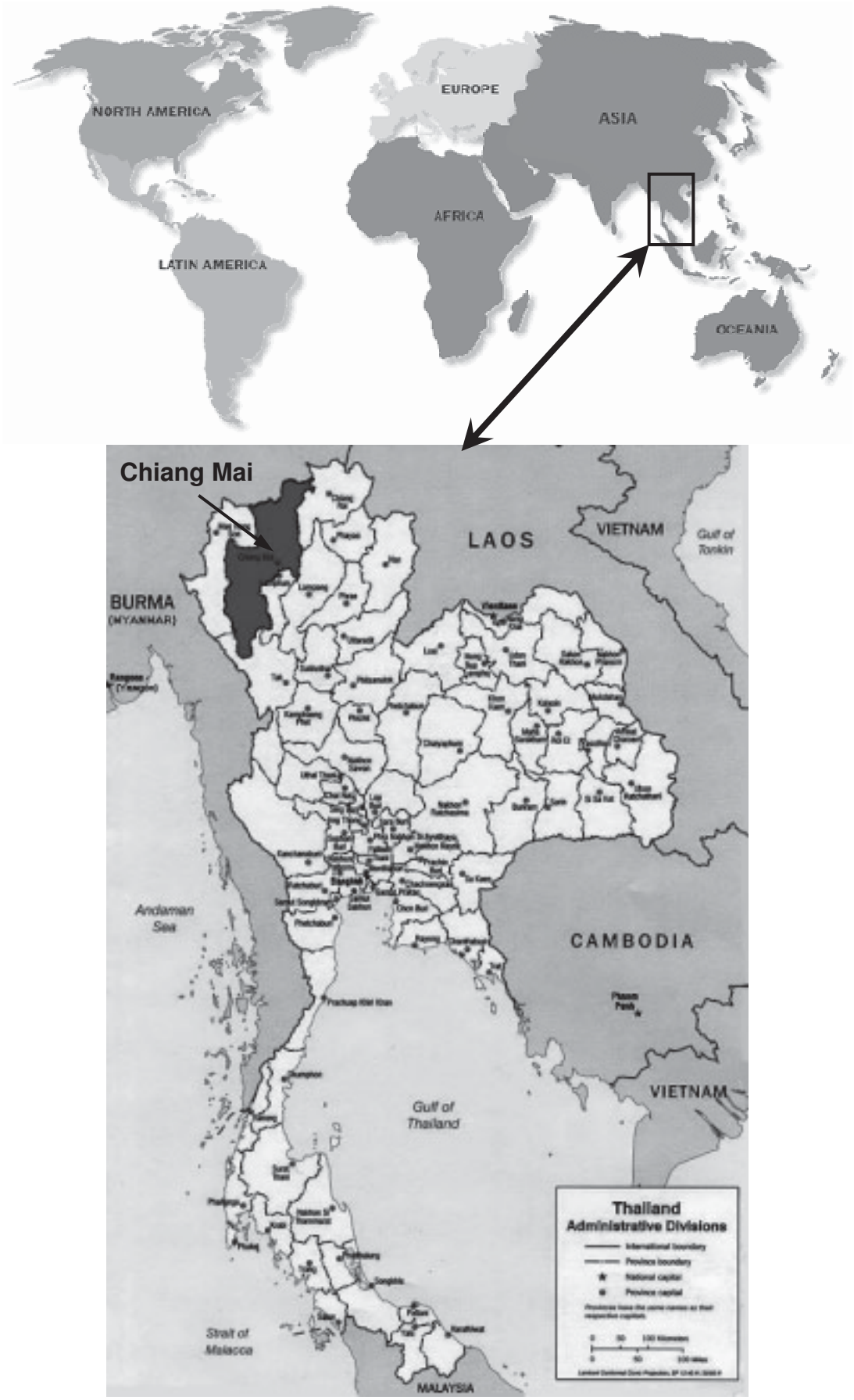

Figure 2.1 Map of Thailand showing Chiang Mai province

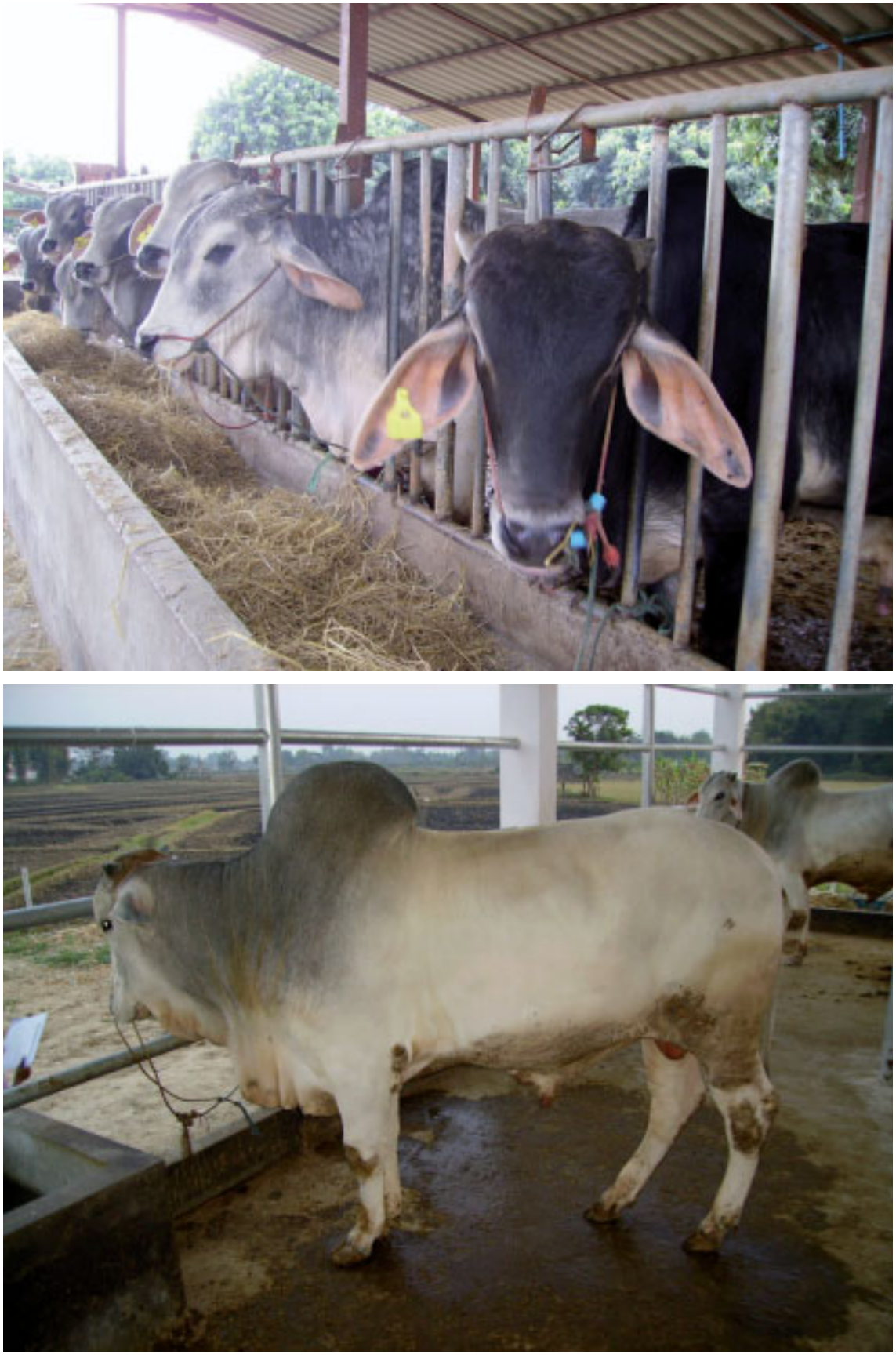

Figure 2.2: Brahman × Thai native crossbred bull (BRA)

Figure 2.3: Charolais × Thai native crossbred bull (CHA)

2.2 Live weight, body muscle score and body measurements

Each animal was weighed at the beginning and the end of the fattening period. Fattening period was recorded and average daily gain during fattening period was calculated. When the animals reached the target slaughter weight, they were transported to a commercial slaughter house in Chiang Mai, where they were fasted for 12 h and weighed afterwards. Before slaughter, body measurements including height at withers and at pelvis, width of chest and of pelvis, and body length according to De Boer *et al*. (1974) were measured (Appendix 1). Body muscle score was evaluated by a 5 score-scale (1 = light muscling, 2 = moderate muscling, 3 = medium muscling, 4 = heavy muscling and 5 = very heavy muscling) according to McKiernan (2006) (Appendix 2).

2.3 Slaughtering and slaughter traits

The animals were slaughtered according to the procedure of the commercial slaughter house by the following steps; stunning by captive bolt stunner, bleeding, heading, shanking, skinning, eviscerate and carcass splitting. Within 1 h p.m., a sample of the *Ld* muscle between the 12^{th} and 13^{th} rib was taken from the right carcass by a 1.5 cm diameter biopsy cannula. The muscle sample was cut into cubes of 1 cm^3, coated with MgO and frozen in liquid nitrogen. Until subsequent muscle fiber area determination the samples were stored at -65°C in a freezer. External (head, legs, skin, tail, tongue and sex organ) and internal organs (lung, heart, liver, kidney, spleen, compound stomach, small intestine and large intestine) were weighed. The percentages of external and internal organs were calculated as fasted weight. Hot carcass weight (without testicle, perirenal and pelvic fat) was recorded and dressing percentage from hot carcass and fasted weight was calculated.

2.4 Carcass quality evaluation

2.4.1 Carcass classification

Hot carcasses were classified with a 5 score-scale for carcass conformation (E or excellent = 5, U or very good = 4, R or good = 3, O or fair = 2 and P or poor = 1)

(Appendix 3) as well as for carcass fat (very high = 5, high = 4, average = 3, slight = 2 and low = 1) (Appendix 4) according to EUROP beef carcass classification system (EC, 1982).

2.4.2 Carcass measurements

The carcass measurements were performed on the right carcass side including carcass length, carcass chest depth, carcass leg length and carcass leg width (De Boer *et al.*, 1974) (Appendix 5).

2.4.3 Carcass tissue compositions

Carcass tissue compositions (muscle, bone plus connective tissue, and fat) were estimated by equations according to Johnson (1979) by using hot carcass side, short-cut tongue and fore shanks weights.

Muscle, g = -998.22 + 0.3126 X_1 + 30.30 X_2 (R = 0.98)

Bone plus connective tissue , g = 393.15 + 4.4932 X_3 (R = 0.94)

Fat, g = 0.98 X_1 - (muscle + bone + connective tissue weight) (R = 0.97)

Where;

X_1 = Hot side weight (g)

X_2 = Short-cut tongue weight (g)

X_3 = Fore shanks weight (g)

2.4.4 Meat pH, colour, loin eye area and marbling score

Carcasses were chilled for 24 h at 4 ℃. Measurements of pH-value ((HI 9025 microcomputer pH meter, Hanna Instruments, Inc., Woonsocket, R.I., U.S.A.) was performed 1 and 24 h p.m. at the 12th rib of the right carcass side. At 24 h p.m., a cut of *Ld* muscle, approximately 12.5 cm long, was removed from the right carcass side between the 10th and 12th rib and brought to meat quality laboratory of Faculty of Animal Science and Technology, Maejo University, Chiang Mai for subsequent evaluation.

Meat colour, loin eye area and marbling score were evaluated from the 12th rib surface of the *Ld* cuts. Meat colour at 24 h p.m. was measured after 1 h blooming at 4 ℃ from the surface of the 12th rib of the *Ld* cut by using a Minolta colour meter (CR-A33f, Minolta, Osaka, Japan). The representation scheme was based on L* a* b* colour coordinates of the CIE (1976). Loin eye area was the measure of the total area of *Ld* muscle by using a transfer and a graph paper (Appendix 6). Marbling score was evaluated at the same surface by using a 6 score-scale (1 = slight, 2 = small, 3 = modest, 4 = moderate, 5 = slightly abundant and 6 = moderate abundant) according to AMSA (2001) (Appendix 7).

2.4.5 Commercial primal cuts

After an ageing period of 14 days at 4℃, a left carcass side was butchered following the local commercial procedure. The carcass side was dissected into commercial primal cuts including blade plus chuck, brisket, rip eye, loin, rump and round (outside flat, topside and knuckle) (Appendix 8). The deboned and trimmed cuts were weighed and percentages of primal cuts were calculated.

2.5 Meat quality evaluation

The *Ld* cut was trimmed to remove residual adipose tissue and epimysium and prepared for further meat quality evaluations (Appendix 9). Two steaks, 2.5 cm thick, were prepared from the *Ld* cut. One steak (steak no. 1) was cut into small pieces, homogenized and stored at -20 ℃ until chemical composition analysis including moisture, ash, crude protein, crude fat, collagen, triglyceride, cholesterol and fatty acids. The other one (steak no. 2) was used to determine drip loss. The remaining *Ld* cut (whole cut) was weighed, packed in plastic bags and aged at 4 ℃ for 14 days. Ageing loss was determined 7 and 14 days p.m. After 14 days ageing, 2 more steaks with the same thickness were prepared from the *Ld* cut and stored at -20 ℃ until boiling and grilling loss analysis. Both steaks were thawed at 4 ℃ for 24 h and thawing loss was calculated. One of the steaks (steak no. 3) was used to determine boiling loss and shear force value. The other steak (steak no. 4) was used to determine grilling loss and subjected for sensory evaluation.