Differences in Carcass and Meat Characteristics Between Chicken Indigenous to Northern Thailand (Black-Boned and Thai Native) and Imported Extensive Breeds (Bresse and Rhode Island Red)

S. Jaturasitha,*[1,2] T. Srikanchai,* M. Kreuzer,† and M. Wicke‡

*Department of Animal Science, Faculty of Agriculture, Chiang Mai University, Chiang Mai, Thailand 50200; †ETH Zurich, Institute of Animal Science, Universitaetstrasse 2, 8092 Zurich, Switzerland; and ‡Institute of Animal Breeding and Husbandry, Georg-August University of Göttingen, Albrecht-Thaer-Weg 3, 37075 Göttingen, Germany

ABSTRACT This study examined the effects of 4 genotypes of chicken, all suitable for extensive fattening, on carcass and meat quality using 320 chickens divided into 4 equally sized groups. The comparison included 2 indigenous chicken strains from Thailand, Black-boned and Thai native (Thai), and 2 imported chicken breeds, Bresse and Rhode Island Red (Rhode, a layer breed). The animals were fed until 16 wk of age. Breast (pectoralis major) and thigh (biceps femoris) muscles were studied in detail. Chickens of the imported breeds were heavier at slaughter than indigenous strains, especially Black-boned chickens. Proportions of retail cuts with bones were similar among genotypes, whereas deboned breast meat and lean:bone ratio were lowest in the layer breed (Rhode). The meat of the Black-boned chickens was darker than that of the other genotypes. Thai and Rhode chickens had a particularly yellow skin. The ratio of red and intermediate to white fibers was higher in the thigh muscle, and the diameter of all muscle fiber types in both muscles was smaller in the indigenous compared with the imported breeds. The meat of the 2 indigenous Thai strains had lower contents of fat and cholesterol compared with that of the imported breeds, especially relative to the Rhode chickens (thigh meat). The meat of the indigenous origins, especially of the Thai chickens, was higher in shear force and collagen content (thigh only) than meat of the imported breeds. The meat lipids of the Thai chickens had particularly high proportions of n-3 fatty acids and a favorably low n-6/n-3 fatty acid ratio compared with the other genotypes. In conclusion, meat of indigenous chickens has some unique features and seems to have more advantages over imported breeds than disadvantages, especially when determined for a niche market serving consumers who prefer chewy, low-fat chicken meat.

Key words: indigenous chicken, muscle, carcass, meat, fatty acid

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INTRODUCTION

White meat such as chicken meat is considered superior in health aspects to red meat because of comparably low contents of fat, cholesterol, and, important for men, iron. Consumers also acknowledge the relatively low price, the typically convenient portions, and the lack of religious restriction against its consumption (Jaturasitha, 2004). Globally, few fast-growing broiler strains, provided by commercial breeding companies, are used to produce chicken meat in intensive fattening systems. Less-intensive fattening is expected to result in leaner carcasses (Khantaprab et al., 1997) and, consequently, in a higher proportion of retail cuts. However, genotype (breed and strain) also plays a major role in carcass fatness (Jaturasitha et al., 2004a; Shahin and Elazeem, 2005; Chaosap and Tuntivisoottikul, 2006). These 2 factors have also repeatedly been shown to influence meat quality, too. Some of the meat quality traits are especially affected by muscle fiber types and sizes (Klont et al., 1998), properties strongly determined by genotype. Concerning the fatty acid profile of the muscle lipids, the effect of genotype is low compared with that of feeding, but a different growth intensity resulting from genotype might still affect fatty acids relevant to human health.

A group of Thai consumers have acquired a preference for the taste of meat from native chicken, still having a small market but with a rapidly growing popularity (Wattanachant et al., 2005). Chicken strains indigenous to Thailand also have traits important for cock fighting (Ausungnern, 1999). This behavioral trait is suspected to result, for instance via a high collagen content, in the development of tough meat when compared with the

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[2]Corresponding author: agisjtrs@chiangmai.ac.th

very tender meat of broilers. Some Thai consumers even prefer meat that is not too tender (chewy) and low in fat at the same time (Jaturasitha et al., 2002). Black-boned chickens and Thai native chickens are such indigenous strains of Thailand, where they are currently reared in the rural and mountainous areas. The dark bones in the Black-boned chickens are another special property searched for by certain consumers, and also the meat is known to be darker (Siriwan et al., 2004). Both indigenous strains are suitable for extensive low-cost scavenging-type production systems. Previous investigations on these strains have aimed at obtaining fundamental data to improve growth performance and carcass traits (Siriwan et al., 2004). However, other imported breeds suitable for extensive fattening have been introduced to Thailand. Bresse chickens, originating from the south of Burgundy County (France), have been imported to Thailand because of their described intensively red meat. Rhode Island Red is a layer breed but is occasionally fattened in Thailand to complement indigenous chickens in times of high demand for meat of indigenous origin such as New Year's celebrations (DLD, 2002).

The objective of the present study was to compare carcass and meat quality traits as well as muscle fiber characteristics in Blacked-boned and Thai chickens as opposed to Bresse and Rhode Island Red chickens to confirm or disprove the hypothesis that the indigenous strains have developed unique features. The results could give indications as to which genotypes should be used for which situation, eventually resulting in an upscaling of the production of meat from such extensive fattening systems based on either native or imported genotypes. Because breast and thigh meat are the major valuable cuts, both meat types were followed in the present study.

MATERIALS AND METHODS

Fattening and Slaughter

The present experiment was conducted based on a completely randomized design (Steel and Terrie, 1980). A total of 320 chickens were fattened in pens of 10 birds from 1 d to 16 wk of age at Chiang Mai Livestock Breeding and Research Center, Chiang Mai, Thailand. Ad libitum access to feed, composed as recommended by NRC (1994), was provided. Each genotype [Black-boned chicken, Thai native chicken (later on called Thai chicken), Bresse chicken, and Rhode Island Red (Rhode chicken)] was represented by 80 birds. Sixty randomly selected chickens of each genotype (equivalent to 7 or 8 birds per pen) were fasted for 12 h, weighed, killed by manual neck cut, bled for 2 min, scalded at 60°C for 2 min, put in a rotary drum picker for 30 s to pluck feathers, and eviscerated as outlined by Jaturasitha (2004). The experiment was approved by the Animal Care and Use Committee of the Livestock Department following the guidelines of the Federation of Animal Science Societies (1999).

Analyses

After chilling for 24 h, all carcasses were dressed by both the international (Henrickson, 1978) and Thai (boneless) cutting style (Jaturasitha, 2004). In all carcasses, pH (model 191, Knick, Berlin, Germany) and electrical conductivity (model LF 196, WTW, Weilheim, Germany) were measured at 45 min and 24 h postmortem (**p.m.**) in the breast muscle at a 2-cm depth. Skin and meat (breast and thigh) color were evaluated at 48 h p.m. with the Chroma Meter (model CR-300, Minolta Camera Co. Ltd., Osaka, Japan) to record lightness, redness, and yellowness (L*, a*, and b*, respectively). From 40 birds per genotype, randomly selected out of the 60 slaughtered animals each, breast (pectoralis major) and thigh muscles (biceps femoris) were harvested during dressing and refrigerated at –20°C until being analyzed.

In the 2 muscles, water-holding capacity was determined as drip loss (according to Honikel, 1987; using half of the slaughtered birds), thawing, and cooking losses (either boiled in a water bath in sealed bags or grilled in a convection oven until an internal temperature of 80°C was reached).

Samples of breast and thigh muscle were taken from a quarter of the samples from the center of the ventral side of these muscles for histological analyses. Serial cross-sections (10-μm thick) were cut and stained for combined ATPase-nicotinamide A dinucleotide diaphorase treatment (modified after Horak, 1983). The density of the histochemical reaction product in the ATPase-nicotinamide A dinucleotide diaphorase staining was determined for each fiber. By using 3 density classes for ATPase, different fiber types could be identified using an image analyzer (LUCIA E600, Nikon, Tokyo, Japan). Muscle fibers are commonly classified into 3 groups according to their biochemical and functional properties (Brooke and Kaiser, 1970; Peter et al., 1972): type I, slow-twitch oxidative (red); type IIA, fast-twitch oxidative-glycolytic (intermediate); and type IIB, fast-twitch glycolytic (white). Because the number of type I fibers is typically very small in poultry muscles (von Lengerken et al., 2002), we decided to combine type I and IIA fibers. The proportion of each fiber type in muscle was determined, and the cross-sectional area (μm^2) of individual myofibers was measured by a microscope at a magnification of 1:10 (Klont et al., 1998). At that occasion, photographs were taken.

Homogenized, uncooked breast and thigh muscles were analyzed for contents of moisture, protein, and fat as outlined by AOAC (1995). Triglyceride and cholesterol concentrations were determined in both muscles after extraction of the fat from the tissue according to Folch et al. (1957). In this extract, triglyceride contents were measured as outlined by Biggs et al. (1975). The extract was further saponified as described by Abell et al. (1951) to eliminate triglycerides. In the remainder, total cholesterol was determined according to Jung et al. (1975). Collagen determinations were performed by a 3-step procedure allowing the separation of soluble

Table 1. Carcass quality of the chickens slaughtered at an age of 16 wk[1]

Item	Chicken genotype				SEM	*P*-value
	Black-boned	Thai	Bresse	Rhode		
Slaughter weight (kg)	1.10[c]	1.28[bc]	1.52[ab]	1.58[a]	0.057	0.001
Dressing (%)	63.7	65.9	63.6	64.4	0.05	0.084
Retail cuts (% of chilled carcass weight)						
Breast with bones	16.6	17.7	18.6	16.1	0.08	0.279
Thigh with bones	20.6	19.6	20.4	19.3	0.09	0.354
Drumstick with bones	16.7	16.7	16.6	17.6	0.04	0.429
Tenderloin (pectoralis minor)	5.8	5.3	5.5	4.2	0.03	0.081
Four-portion cut	60.0	59.3	61.2	57.2	0.11	0.290
Thai cutting style without bone (% of chilled carcass weight)						
Breast	12.5[ab]	15.5[a]	14.8[a]	11.7[b]	0.05	0.002
Thigh	13.4	13.0	13.3	12.7	0.04	0.673
Drumstick	10.6	10.5	10.7	10.6	0.04	0.997
Tenderloin	5.8	5.3	5.5	4.2	0.03	0.081
Total lean	50.8	50.4	53.1	48.2	0.11	0.095
Bone	43.7[ab]	41.4[b]	41.0[b]	45.2[a]	0.08	0.010
Lean:bone ratio	1.17[ab]	1.23[ab]	1.30[a]	1.08[b]	0.004	0.022

[a–c]Means within a row with no common superscripts are significantly different ($P < 0.05$).

[1]n = 60 per genotype.

and insoluble collagen as described by Hill (1966). Separation was performed by centrifugation (Polytron PT 1200B, Kinematic AG, Littau, Switzerland) for 1 min at 3,540 × *g*. This was followed by hydrolysis and ultraviolet detection in the 2 fractions of hydroxyproline at a 558-nm wavelength with a spectrophotometer (Gynesys, Spectronic Instruments Inc., New York, NY) as suggested by Bergman and Loxley (1963).

Shear values of the boiled breast and thigh muscles were determined in six 1.27-cm diameter cores cut perpendicular to the muscle fibers using a Warner-Bratzler shear device attached to a universal testing machine (model 5565, Instron Ltd., Buckinghamshire, UK). A crosshead speed of 200 mm/min and a 5-kN load cell calibrated to read over range of 0 to 100°N were applied.

The fatty acid profile of breast and thigh muscle lipids was analyzed in the lipids extracted by chloroform and methanol (2:1 vol/vol; Folch et al., 1957). Fatty acid methyl esters were prepared by the method of Morrison and Smith (1964) and quantified by a gas chromatograph (model GC-2010, Shimadzu, Tokyo, Japan) equipped with a 0.25 mm × 30 m × 0.25 μm wall-coated fused wax capillary column. The temperature of the oven was programmed with an initial temperature of 160°C, held for 2 min, and a final temperature of 230°C, held for 5 min. The temperature was increased at a rate of 5°C/min. Injector and detector temperatures were 230 and 280°C, respectively. Helium was used as a carrier gas, and flow rate was 1 mL/min when measured at the outlet terminal. Split ratio of injector was approximately 1:50. Eluting peaks were identified by comparison with retention time of known mixed standards (Supelco 37, Bellefonte, PA).

Statistical Analyses

Data were subjected to ANOVA by the GLM procedure considering genotype as effect and animal within genotype (replicate) as random effect using SAS (2001; version 8.2 for Windows). Comparisons among treatment means were carried out by Tukey's method. The tables give the least square mean values for the genotypes, the corresponding SEM, and the probabilities of error (*P*-value).

RESULTS AND DISCUSSION

Carcass Characteristics

Live weights at slaughter at the same age clearly differed ($P < 0.001$) among genotypes (Table 1), with a lower growth rate of the indigenous genotypes, especially Black-boned chickens, compared with the imported, moderately improved, genotypes, even though there were also certain attempts to improve Black-boned chickens (Siriwan et al., 2004). Chickens from indigenous origin in the present study were still better-growing than AC chickens (Black-boned) in Vietnam, where Phuong (2002) reported a slaughter weight of 495 g at 12 wk of age, whereas the growth of the imported breeds was far lower than that of commercial broiler strains. Similar growth differences have also been found when comparing indigenous Thai and crossbred (Thai × Rhode) chickens (Jaturasitha et al., 2002). Dressing percentage did not differ ($P > 0.05$) among genotypes, and there were also no clear differences in most traits among genotypes in retail cuts with bones and cuts obtained via Thai cutting style when expressed as percentages of chilled carcass weights. However, bone proportion was high and lean:bone ratio was low in Rhode chickens ($P < 0.05$ against Bresse chickens). Additionally, breast proportion in deboned material (Thai cutting style), but not in the bone-containing retail cuts, was low in Rhode followed by the Black-boned chickens. This can probably be explained by the fact that Rhode is basically a layer breed

Table 2. The pH, conductivity, color, and water-holding capacity of the meat of the chickens[1]

Item	Chicken genotype				SEM	*P*-value
	Black-boned	Thai	Bresse	Rhode		
Breast meat pH and electrical conductivity (EC)						
$pH_{45\ min}$	5.95	5.86	5.92	5.96	0.006	0.902
$pH_{24\ h}$	5.88	5.77	5.88	5.86	0.003	0.196
$EC_{45\ min}$ (mS/cm)	4.69	4.00	6.86	4.02	0.027	0.137
$EC_{24\ h}$ (mS/cm)	5.26	5.33	5.57	5.32	0.027	0.924
Meat color						
Breast						
L*	50.7[b]	54.9[b]	54.8[b]	61.6[a]	0.09	0.001
a*	1.66[a]	1.27[a]	2.98[a]	–0.60[b]	0.036	0.001
b*	10.5[b]	13.6[a]	8.4[c]	14.1[a]	0.03	0.001
Thigh						
L*	45.9[c]	51.9[b]	52.0[b]	55.5[a]	0.06	0.001
a*	3.87[ab]	5.27[a]	5.22[a]	3.53[b]	0.033	0.007
b*	3.4[b]	7.8[a]	4.3[b]	7.3[a]	0.04	0.001
Skin color						
Breast						
L*	71.7[a]	68.5[b]	40.1[d]	63.2[c]	0.03	0.001
a*	7.62[a]	4.32[b]	4.98[b]	7.68[a]	0.010	0.001
b*	4.2[c]	23.2[a]	–0.6[d]	16.3[b]	0.02	0.001
Thigh						
L*	68.4[b]	67.6[b]	42.8[c]	73.2[a]	0.02	0.001
a*	8.30[a]	3.95[b]	4.39[b]	7.47[a]	0.016	0.001
b*	6.2[c]	19.1[a]	0.8[d]	10.0[b]	0.02	0.001
Water-holding capacity (loss, % of total)						
Breast meat						
Drip	8.26	10.39	8.43	11.14	0.253	0.690
Thawing	5.54	3.64	4.67	5.42	0.074	0.140
Boiling	22.08	18.99	22.10	22.89	0.179	0.277
Grilling	24.65	20.66	19.18	20.16	0.298	0.418
Thigh meat						
Drip	4.22	3.42	3.66	4.09	0.177	0.975
Thawing	3.87	2.73	3.12	2.99	0.220	0.423
Boiling	20.12	23.38	22.70	19.92	0.061	0.423
Grilling	30.21[a]	27.65[ab]	21.06[b]	24.48[ab]	0.245	0.032

[a–d]Means within a row with no common superscripts are significantly different ($P < 0.05$).

[1]n = 20.

and therefore not selected for lean proportion (Kasetsuwan, 1995).

Physiochemical Characteristics and Water-Holding Capacity

The pH and electrical conductivity values measured in the breast muscle at 45 min and 24 h p.m. were not significantly different among genotypes (Table 2). This could reflect favorable conditions during transport and slaughter (resting period). Even though the indigenous strains are known to have a more aggressive and alert behavior than the imported breeds (Jaturasitha et al., 2004a), all of the genotypes investigated probably were less stress-susceptible than high-bred broiler strains anyway. The pH level was similar to that of 5.92 reported by Arslan (2006) for the breast meat of spent hens.

Breast and thigh meat color, described by L*, a*, and b* values, were largely different among genotypes ($P < 0.001$). Breast and thigh of Rhode chickens were paler (high L*), more yellow (high b*), and less red (low a*) than that of all other genotypes, whereas Bresse chicken meat had the expected relatively intensive red color, the trait which, among others, led to its introduction in Thailand. Within the indigenous strains, meat of Black-boned chickens was slightly darker (significant in thigh muscle and corresponding to the dark bones), whereas the meat of the Thai chickens had a higher redness. Similarly, Jaturasitha et al. (2004a) and Chaosap and Tuntivisoottikul (2006), studying Thai and other indigenous strains, found darker and redder, but less yellow, meat compared with broilers. The skin of the Bresse chickens was lighter and less yellow compared with the other genotypes. Breast and thigh skin had a higher ($P < 0.05$) redness in Black-boned and Rhode chickens than in Thai and Bresse chickens, and Thai chickens had a very yellow skin. The latter is consistent with description of visual appearance, whereas the also typically observed darker color of the skin of the Black-boned chickens (Wattanachant et al., 2004) was not reflected by the color measurements in the present experiment. Meat and skin color are influenced by various factors including heme pigments, genetics, and feeding (Fletcher, 1999; Xiong et al., 1999), and the present study confirmed the presence of a strong genetic influence.

The indicators of water-holding capacity of breast and thigh meat mostly were not significantly different

Table 3. Muscle fiber[1] counts and size in the chickens[2]

Item	Chicken genotype				SEM	*P*-value
	Black-boned	Thai	Bresse	Rhode		
Breast muscle						
Fiber count (% of total)						
Type I and IIA	5.7	7.2	3.9	5.5	0.18	0.135
Type IIB	94.3	92.8	96.1	94.5	0.31	0.860
Cross-sectional area (diameter, μm^2)						
Type I and IIA	21.5^{c}	17.7^{d}	26.3^{b}	36.5^{a}	0.03	0.001
Type IIB	47.8^{c}	45.7^{d}	52.5^{a}	48.9^{b}	0.00	0.001
Thigh muscle						
Fiber count (% of total)						
Type I and IIA	34.0^{ab}	39.0^{a}	31.2^{bc}	25.8^{c}	0.35	0.001
Type IIB	66.0^{b}	61.0^{c}	68.8^{b}	74.2^{a}	0.34	0.001
Cross-sectional area (diameter, μm^2)						
Type I and IIA	31.8^{d}	33.9^{c}	41.1^{a}	36.4^{b}	0.01	0.001
Type IIB	54.8^{b}	55.5^{b}	60.3^{a}	59.9^{a}	0.00	0.001

[a–d]Means within a row with no common superscripts are significantly different ($P < 0.05$).

[1]Type I = slow-twitch oxidative (red); type IIA = fast-twitch oxidative-glycolytic (intermediate); type IIB = fast-twitch glycolytic (white).

[2]n = 10.

among genotypes. Joseph et al. (1997) reported that fat loss from high temperature (85°C) caused increasing fluid loss in meat, but the internal temperatures of the samples investigated in the current study did not exceed 80°C. One exception for genotype differences in water-holding capacity was that the thigh meat of Black-boned chickens had higher ($P < 0.05$) grilling losses than that of Bresse chickens, with the other genotypes ranging in between. This may have been the result of the small size of the muscles of the Black-boned chickens (grilling loss was numerically highest also in breast muscle), making it easier to lose water compared with larger pieces of meat (Jaturasitha et al., 2004a).

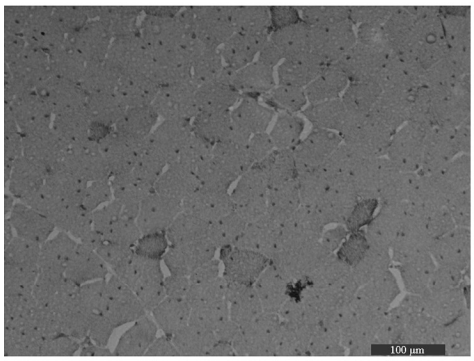
Histological Properties

There was no significant difference in the proportions of fiber types in breast muscle among genotypes, with the white fibers accounting for 93 to 96% of the total (Table 3). The dominance of this fiber type is also obvious from Figure 1. Von Lengerken et al. (2002) even found 99.5 and 99.8% of white fibers in the pectoralis muscle of broilers and turkeys, respectively. In the thigh muscle, the indigenous strains, especially when compared with Rhode chickens, had more ($P < 0.05$) red and intermediate fibers at the cost of white fibers (with the latter being much lower in percentage compared with the breast muscle in all groups; Figure 1). In the imported breeds, this probably reflects breeding for higher muscle accretion, which is often associated with a shift from oxidative to glycolytic muscle metabolism (Jurie et al., 1995) and, at very high selection intensity (which is probably not yet the case for Bresse and Rhode), a higher frequency of meat-quality problems. The cross-sectional areas of the breast muscle fibers, independent of their type, were smallest in Thai chickens, intermediate in Black-boned chickens, and highest in the imported breeds ($P < 0.05$). In thigh muscle, no such difference was found between the indigenous strains, but the difference to the imported breeds persisted. These results are in a certain contrast to Wattanachant et al. (2005), who found a larger fiber diameter in breast and thigh muscles in Thai indigenous chicken than in that of broilers.

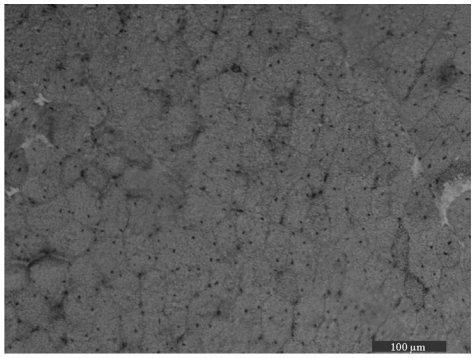
Chemical Composition and Texture

Moisture and protein contents of the breast muscles did not significantly differ among genotypes (Table 4). In thigh muscle, higher moisture and protein contents were found in the indigenous strains ($P < 0.05$ between several groups). Nowsad et al. (2000) reported higher moisture and less protein in the meat of spent hens compared with that of broilers, whereas Shaarani et al. (2006) found moisture contents of broiler meat being as high as 76%. The i.m. fat content of the breast muscle was lower in the 2 indigenous strains compared with the imported breeds ($P < 0.05$ when comparing Thai and Bresse). Triglyceride contents were not as clearly different as i.m. fat content. In thigh muscle, i.m. fat and triglyceride contents varied among treatments to a larger extent, being low in the indigenous strains and 1.5 and 2 to 3 times higher in Bresse and Rhode chickens, respectively. Cholesterol was far lower ($P < 0.05$) in the breast and thigh meat of the indigenous strains compared with the imported breeds. Also, Jaturasitha et al. (2002) found lower cholesterol contents in the meat of Thai chickens compared with that of broilers. Reasons for that might be sought in selection for growth and fat retention (Lawrie, 1998), with the latter being sometimes associated with increased cholesterol deposition.

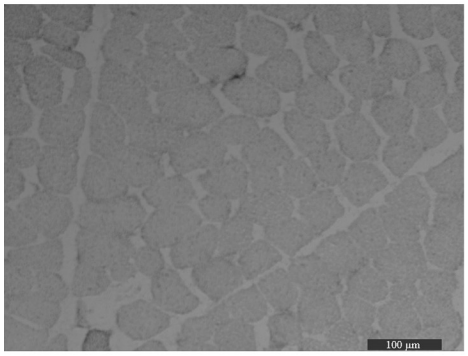
Contents of soluble and insoluble collagen in breast muscle were not significantly different among groups, whereas values were low with Bresse chickens compared with the other genotypes ($P < 0.05$ relative to Thai chick-



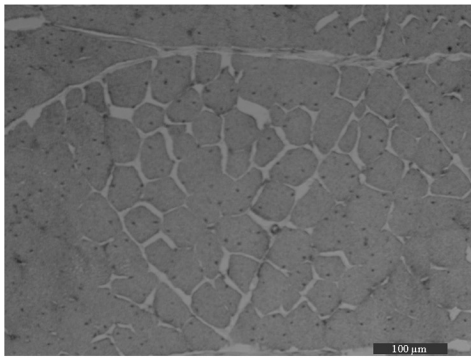
Breast muscle: Black-bone chicken



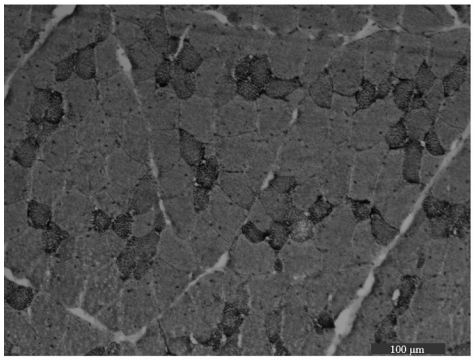
Breast muscle: Thai chicken



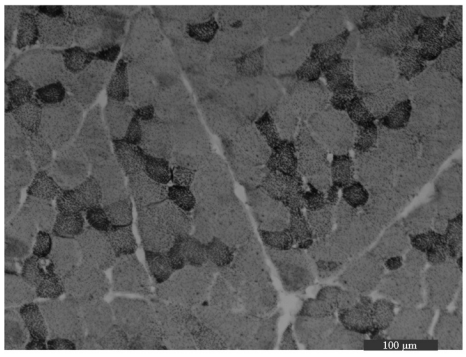
Breast muscle: Bresse chicken



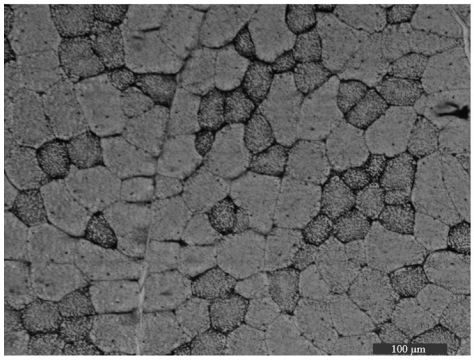
Breast muscle: Rhode Island Red chicken



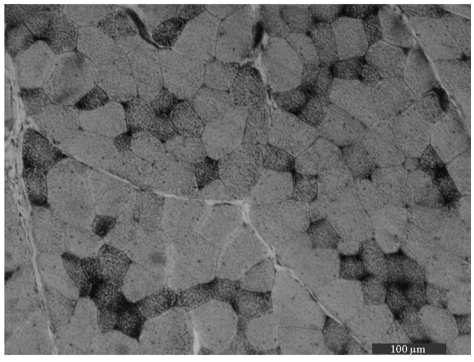
Thigh muscle: Black-bone chicken



Thigh muscle: Thai chicken



Thigh muscle: Bresse chicken



Thigh muscle: Rhode Island Red chicken

Figure 1. Microscopic view of the cross-section of breast and thigh muscles of the chickens. Bar on lower right corner of each panel = 100 µm.

Table 4. Chemical composition, texture, and sensory grading of meat from the chickens[1]

Item	Chicken genotype				SEM	*P*-value
	Black-boned	Thai	Bresse	Rhode		
Breast muscle						
Chemical composition (g/100 g)						
Moisture	72.1	72.9	73.3	73.7	0.05	0.210
Protein	24.4	24.7	23.6	24.8	0.06	0.561
Fat	0.53^{ab}	0.51^{b}	0.76^{a}	0.72^{ab}	0.006	0.013
Triglycerides (g/100 g)	0.48	0.37	0.47	0.54	0.004	0.288
Cholesterol (mg/100 g)	27.9^{b}	30.5^{b}	36.5^{a}	40.5^{a}	0.091	0.001
Collagen (mg/g)						
Soluble	11.2	11.4	10.4	10.4	0.11	0.903
Insoluble	17.1	14.8	14.4	16.7	0.15	0.580
Shear values						
Force (N)	41.7^{ab}	51.2^{a}	35.8^{ab}	26.3^{b}	0.43	0.037
Energy (mJ)	184^{ab}	225^{a}	139^{ab}	118^{b}	2.0	0.040
Extension (mm)	18.1^{ab}	19.5^{a}	17.7^{b}	18.2^{ab}	0.03	0.041
Thigh muscle						
Chemical composition (g/100 g)						
Moisture	74.1^{ab}	75.7^{a}	73.7^{b}	72.8^{b}	0.05	0.003
Protein	21.7^{a}	20.4^{ab}	20.6^{ab}	20.1^{b}	0.04	0.053
Fat	2.81^{b}	2.94^{b}	4.21^{b}	6.04^{a}	0.041	0.001
Triglycerides (g/100 g)	2.07^{bc}	1.50^{c}	3.24^{b}	6.15^{a}	0.023	0.001
Cholesterol (mg/100 g)	53.9^{b}	58.7^{b}	67.2^{ab}	83.3^{a}	0.35	0.002
Collagen (mg/g)						
Soluble	14.6^{ab}	16.7^{a}	9.5^{b}	12.7^{ab}	0.14	0.020
Insoluble	21.7^{ab}	25.5^{a}	18.8^{b}	20.6^{ab}	0.15	0.053
Shear values						
Force (N)	36.1^{ab}	44.3^{a}	28.1^{b}	42.6^{a}	0.25	0.009
Energy (mJ)	132^{ab}	171^{a}	80^{b}	160^{a}	1.3	0.004
Extension (mm)	17.8	17.5	17.6	18.6	0.03	0.173

$^{a–c}$Means within a row with no common superscripts are significantly different ($P < 0.05$).

[1]n = 20.

ens) in thigh muscle. In the present study, the birds had been slaughtered at the same age and, therefore, could not have differed in collagen content because of age (Dawson et al., 1991) but mainly because of genotype. Here the mentioned cock-fighting behavior might indeed have contributed to collagen contents. The shear force of the breast muscle of Rhode chickens was lower ($P < 0.05$) by a factor of almost 2 compared with the Thai chickens, with the other 2 genotypes ranging in between. Ranking was different for extension, reflecting chewiness, which was lowest in Bresse breast meat. In thigh meat, shear force was lowest in Bresse and not in Rhode chickens, whereas extension did not differ significantly among genotypes. Also, Nute (1999) reported panelists to judge the texture of improved chicken genotypes to be more favorable than that of indigenous strains. This was consistent with differences in texture described by Wattanachant et al. (2004) for Thai indigenous strains and broilers. Reasons for the differences found in shear values might be several. Age effects, as particularly apparent from comparisons of meat from layers (72 wk) and broilers (Lee et al., 2003), had been deliberately excluded. Muscle fiber size also does not appear to have caused the differences in shear values, because these were larger in the imported genotypes, thus leaving fiber type as a possible source of variation of shear values. Additionally, in thigh muscle, collagen content probably explained a large part of the genotype differences in shear values (Klandorf et al., 1996; De Smet et al., 1998), whereas in breast muscle, with its smaller variation in collagen among genotypes, shear force differences had been correspondingly smaller.

Fatty Acid Composition

Various fatty acids were different in proportion among genotypes, but not all differences were similar in both muscles (Table 5). Nevertheless, some differences were characteristic for certain genotypes. Meat of Black-boned chickens had relatively low contents of saturated fatty acids and, in breast muscle, high contents of polyunsaturated fatty acids compared with the other genotypes ($P < 0.05$ relative to several other genotypes, each). In previous studies (Qiao et al., 2002; Jaturasitha et al., 2004b; Wattanachant et al., 2004), lipids from indigenous chickens other than Black-boned chicken were found to be similarly different from that of layer breeds. Thai chicken meat was characterized by relatively low C18:1*trans* fatty acids and high proportions of individual and total n-3 fatty acids and had a favorable n-6/n-3 fatty acid ratio ($P < 0.05$ in thigh meat). Differences in fatty acid profile were mostly less pronounced between the 2 imported breeds.

Conclusions

The present study revealed several different characteristic features for the 2 indigenous strains chosen for the

Table 5. Fatty acid[1] composition of the meat of the chickens[2]

Item	Chicken genotype				SEM	*P*-value
	Black-boned	Thai	Bresse	Rhode		
Breast muscle	% of total analyzed fatty acids					
C12:0	0.32^{ab}	0.57^{a}	0.27^{b}	0.53^{ab}	0.005	0.013
C14:0	1.20^{a}	0.72^{b}	0.93^{ab}	0.61^{b}	0.005	0.001
C16:0	24.50^{c}	27.00^{ab}	28.22^{a}	25.18^{bc}	0.033	0.001
C16:1	2.65^{b}	3.46^{ab}	4.27^{a}	2.97^{ab}	0.022	0.012
C18:0	8.75	8.05	8.24	8.58	0.015	0.157
C21:0	0.16^{bc}	0.35^{a}	0.13^{c}	0.30^{ab}	0.003	0.001
C23:0	0.35	0.54	0.55	0.57	0.005	0.268
C24:0	0.13^{b}	1.00^{a}	0.32^{b}	0.90^{a}	0.010	0.001
C18:1n-9	24.22	23.82	24.10	24.35	0.046	0.963
C18:1*trans*	1.47^{b}	1.63^{a}	1.63^{a}	1.63^{a}	0.002	0.001
C20:1	0.44^{a}	0.18^{c}	0.33^{ab}	0.30^{b}	0.002	0.001
C18:2n-6	31.33^{a}	26.38^{b}	27.04^{b}	27.58^{b}	0.032	0.001
C20:2	0.26^{a}	0.03^{b}	0.09^{b}	0.11^{b}	0.002	0.001
C18:3n-3	0.68^{a}	0.52^{ab}	0.61^{ab}	0.46^{b}	0.033	0.005
C20:4n-6	2.36	3.72	2.25	4.03	0.036	0.062
C22:6n-3	1.19	2.03	1.04	1.90	0.019	0.050
Total SFA	35.41^{c}	38.23^{ab}	38.65^{a}	36.68^{bc}	0.031	0.001
Total MUFA	28.78	29.08	30.33	29.25	0.064	0.729
Total PUFA	35.81^{a}	32.69^{ab}	31.02^{b}	34.08^{ab}	0.063	0.010
Total n-6 FA	33.68^{a}	30.10^{b}	29.29^{b}	31.60^{ab}	0.048	0.001
Total n-3 FA	1.87	2.55	1.64	2.36	0.017	0.076
n-6/n-3	21.06	15.24	22.16	16.33	0.131	0.056
Thigh muscle						
C12:0	0.33^{b}	0.63^{a}	0.53^{a}	0.28^{b}	0.003	0.001
C14:0	0.81	0.75	0.71	0.77	0.002	0.137
C16:0	25.82^{b}	27.46^{a}	26.61^{ab}	26.00^{b}	0.020	0.002
C18:0	7.61^{b}	9.82^{a}	8.43^{b}	8.71^{ab}	0.019	0.001
C21:0	0.13^{b}	0.35^{a}	0.21^{ab}	0.16^{b}	0.003	0.018
C23:0	0.34^{b}	0.57^{a}	0.47^{ab}	0.35^{b}	0.003	0.005
C24:0	0.41^{b}	0.90^{a}	0.59^{ab}	0.62^{ab}	0.007	0.032
C16:1	3.78^{a}	2.59^{b}	3.11^{ab}	2.96^{ab}	0.015	0.011
C18:1n-9	25.11^{a}	21.17^{b}	24.71^{a}	25.43^{a}	0.028	0.001
C18:1*trans*	1.55^{b}	1.67^{ab}	1.73^{a}	1.54^{b}	0.003	0.005
C20:1	0.31^{a}	0.08^{b}	0.28^{a}	0.33^{a}	0.002	0.001
C18:2n-6	29.17^{a}	24.45^{b}	26.11^{b}	28.21^{a}	0.031	0.001
C20:2	0.06	0.05	0.05	0.04	0.002	0.964
C18:3n-3	0.58	0.68	0.51	0.68	0.003	0.032
C20:4n-6	2.58^{b}	5.92^{a}	3.95^{b}	2.75^{b}	0.032	0.001
C22:6n-3	1.42^{bc}	2.91^{a}	2.00^{b}	1.17^{c}	0.013	0.001
Total SFA	35.45^{c}	40.48^{a}	37.55^{b}	36.88^{b}	0.022	0.001
Total MUFA	30.75^{a}	25.52^{b}	29.83^{a}	30.27^{a}	0.041	0.001
Total PUFA	33.80	34.01	32.62	32.05	0.032	0.167
Total n-6 FA	31.75^{a}	30.37^{ab}	30.07^{b}	30.96^{ab}	0.024	0.014
Total n-3 FA	2.00^{b}	3.59^{a}	2.51^{b}	1.85^{b}	0.014	0.001
n-6/n-3	18.01^{a}	9.77^{b}	13.29^{ab}	17.42^{a}	0.080	0.001

$^{a–c}$Means within a row with no common superscripts are significantly different ($P < 0.05$).

[1]SFA = saturated fatty acids; MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids; FA = fatty acids.

[2]n = 20.

present investigation. Apart from meat color, this included muscle fiber diameter, texture, and fatty acid profile. Both strains clearly differed from the imported breeds in some aspects (shear force). In the 2 alternatives of extensive imported breeds, Bresse was preferable to the layer breed due to its lower bone proportion and the intensive red meat color, meeting the preference of those consumers looking for chicken meat in this niche market. From a health point of view, the indigenous strains, especially Thai native chicken, seem superior, because fat and cholesterol contents were low (both strains) and the fatty acid profile was favorable (Thai). The indigenous strains therefore have the potential to provide a successful product for a niche market serving consumers who prefer low-fat chicken meat, because from several studies, it is known that a large proportion of Thai people prefer chewy chicken meat to the soft broiler meat (Khiaosa-ard et al., 2004; Siriwan et al., 2004; Wattanachant et al., 2004).

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