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Chemical and Physical Properties of Raw and Cooked Spent Hen, Broiler and Thai Indigenous Chicken Muscles in Mixed Herbs Acidified Soup (Tom Yum)

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Abstract: Chemical and physical properties of Thai indigenous chicken, spent hen and broiler pectoralis and biceps femoris muscles were investigated before and after heating in mixed herbs acidified soup (Tom Yum). Raw muscles of Thai indigenous chicken contained higher protein and fat but lower in ash content, compared to spent hen and broiler muscles ($p<0.05$). Spent hen biceps femoris muscle had significantly higher total collagen content but less soluble collagen among the breeds ($p<0.05$). Heating under Tom Yum soup (pH 2.8, 95°C) decreased the collagen content and increased soluble collagen of chicken muscles leading to decrease shear value of chicken muscles especially in spent hen muscles. L*, a*, b* values of all breeds chicken muscles were increased after cooking. The indigenous chicken and spent hen biceps femoris muscles exhibited the higher shear force value with the higher cooking loss than those of broiler muscles ($p<0.05$). After thermal process in Tom Yum soup at 116 and 121°C to an F_0 value of 6.0, there were no significant differences between treatments for shear values, total collagen and sensory characteristics of spent hen muscles ($p>0.05$). However, process at lower temperature increased more soluble collagen ($p<0.05$).

Key words: Thai indigenous chicken, broiler, spent hen, properties of chicken muscles, heating process, mixed herbs acidified soup

INTRODUCTION

Broiler and Thai indigenous chicken are commercially produced for meat consumption in Thailand. While spent hen is mostly underutilized and used in low priced mince product at the end of egg laying cycle. These birds become available for use in further processed product (Nowsad *et al*., 2000). However, meat obtained from these birds has poor functional properties (Singh *et al*., 2001). The spent hen meat is very tough in comparison to those of broilers due to its higher collagen content and its thus not well accepted by the consumer. The indigenous chicken muscles, both pectoralis major and biceps femoris muscles, posses firmer textures, particularly after cooking than those of the broilers has been reported (Wattanachant *et al*., 2004). Therefore, meat obtained from different chicken breeds, ages and muscle types results difference in their properties which need to be processed for specific products. Tom Yum, mixed herbs acidified soup, a traditional Thai food has been regarded as a great delicacy and becomes very popular among Thai and foreigner consumers. However, the acid condition (pH 2.8-3.0) of Tom Yum soup may cause deterioration in texture and colour of meat resulting in short shelf-life of product. The tough chicken meat with high collagen content and low amount of heat soluble collagen may be suitable for this product condition. The acid solution was found to have significant effects on pH, mass variation and water content in chicken meat (Deumier, 2006, 2004). Raw chicken was lightened in colour after immersing in lactic or citric solution. Deumier (2004) reported the decrease in colour a value of chicken meat as the processing time and acid concentration of the solution increased.

Thermal processing in meat and poultry strongly influences texture, protein changes, cooking yield and other important quality factors such as juiciness, colour and flavour (Dawson *et al*., 1991; Voller-Reasonover *et al*., 1997; Wattanachant *et al*., 2005a). The principle proteins responsible for meat texture include stromal (mostly collagen) and myofibrillar proteins (Dawson *et al*., 1991; Califano *et al*., 1997). The increment in collagen content and collagen cross-linking in meat (often associated with older animals and specific muscle types) will increase the toughness of cooked meat (Dawson *et al*., 1991). Cooking of meat changes the structure of the intramuscular connective tissue and its mechanical properties, because of denaturation of the

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collagen (Palka, 1999; Christensen *et al*., 2000). Retorting with high temperature denatures the triple helical structure of collagen, which can tenderize the meat. Improvement in the textural and yield characteristics of aseptically processed chicken breast was reported by Dawson *et al.* (1991). However, unacceptable texture characteristics, including toughening, drying and loss of particulate shape, were observed after high temperature process (Voller-Resonover *et al*., 1997).

The objectives of this study were to compare the chemical and physical properties of meat from different breeds and muscle types before and after heating in Tom Yum soup condition and to determine the effects of thermal processing temperature on the chemical and physical properties of chicken muscle in Tom Yum soup condition.

MATERIALS AND METHODS

Raw materials: Mix-sex Thai indigenous chickens (Kaidang, *Gallus domesticus*) aged 16 wk raised under the intensive farming system, spent hen (*H* and *M Brown Nick*) aged 52 week and commercial broiler (*CP707*) aged 38 days of similar life weights (1.8-2.0 kg) were obtained 30 birds of each from farm in Department of animal science, Prince of Songkla University. All chickens were killed by the method mentioned in Wattanachant *et al*. (2004): By conventional neck cut, bled for 2 min, scalded at 60°C for 2 min, plucked in a rotary-drum picker for 30 sec and eviscerated. Pectoralis major and biceps femoris muscles were dissected from the carcasses after chilling at 4°C for 24 h. The skin was removed and the muscles were trimmed of obvious fat and connective tissue. Muscle samples from each of 10 birds of each breed were stored at 4°C until analysis for cooking loss, colour, shear force values and muscle structure within 2 days. The muscle samples from each of 10 birds of each breed were minced, placed in plastic bags and stored frozen (-20°C) until used for chemical analysis. Muscle samples from each of 10 birds of each breed were stored at 4°C until cooking in Tom Yum soup within 3 days.

Tom Yum soup preparation: Tom Yum soup was prepared according to the method of Siripongvutikorn (2004). Tom Yum ingredients were composed of lemon grass, galangal, red onion, garlic, kaffirlime leave, chili, coriander root, garcinia, salt and sugar. The acid condition of the soup was performed by dried garcinia. All ingredients were minced and boiled in water for 5 min. The soup was filtered through thin layer cloth to separate the solid parts. The pH of Tom Yum soup was in range 2.8-3.0.

Cooking under Tom Yum soup condition: Pectoralis and biceps femoris muscle samples were cut to size of 1.5×3.0×0.5 cm. and precooked in water at temperature of 80°C for 10 min. The precooked muscles were weighed and cooked in Tom Yum soup with the ratio 1:2 for 20 min at 95°C. The muscles in Tom Yum soup were cooled to room temperature and kept at 4°C for 24 h before physical and chemical property analysis.

Thermal processing under Tom Yum soup condition: Pectoralis and biceps femoris muscle of spent hen were cut to size of 1.5×3.0×0.5 cm. and precooked in water at temperature of 80°C for 10 min. The precooked muscles were weighted and packed in retort pouch size 8.5×15 cm (10 pieces per pouch). Tom Yum soup was filled in the ratio 1:2 (w/w) for chicken muscle per soup. The pouch of samples were sealed and processed in over pressure steam retort (FMC Food Tech, German) at 116°C and 121°C to an F_0 value of 6.0. The samples were cooled to room temperature and kept for 24 h before analyses.

Analyses: Cooking losses were calculated from differences in the weight of raw and cooked muscle strips (Wattanachant *et al*., 2005a). The colour of muscles in the anterior and posterior locations was determined using a Hunterlab colourimeter and reported as the complete International Commission on Illumenation (CIE) system colour profile of L*, redness (a*) and yellowness (b*) (Wattanachant *et al*., 2005a). Muscle samples, raw and cooked, were cut to size of 1.0×2.0×0.5 cm for shear analysis using the Texture Analyzer (TA-XT2i, Stable MicroSystem, Godalming, Surrey UK.) equipped with Warner-Bratzer shear apparatus (Wattanachant *et al*., 2004). The operating parameters consisted of a cross-head speed of 2 mm s^{-1} and a 25-kg load cell. The shear force perpendicular to the axis of muscle fibers was measured. The peak of the shear force profile was regarded as the shear force value.

The microstructure of muscle samples was determined using a Scanning Electron Microscope (SEM) according to Wattanachant *et al*. (2005b) which modified method of Palka and Daun (1999). Pieces (1×1×0.5 cm) were excised from pectoralis and biceps femoris muscles and fixed in 2.5% glutaraldehyde in 0.1 M phosphate buffer, pH 7.3, for 2 h at room temperature. The specimens were then rinsed with distilled water and dehydrated in a serial solution of 25, 50, 70, 95% and absolute ethanol (twice), for 1 h in each solution, The sample were cut in liquid nitrogen using a razor blade. The fragments of dried specimens were mount on aluminum stubs and coated with gold. The specimens were examined and

photographed in a on a JSM 5200 scanning electron microscope (JEOL, Ltd., Akishima, Japan). The micrographs and video prints were taken at magnification of 500× for transverse sections and 10,000× for longitudinal ones. The area of muscle fibres and the length of sarcomeres were measure in video prints, using a special morphometric facility. Three videoprints from each sample were taken for transverse sections and 10 measurements of fibre area on each were made (n = 30). The fibre diameter was calculated from the fibre area. Three videoprints from each sample were taken for longitudinal sections and 10 measurements of sarcomere length on each were made (n = 30).

The pH of muscle was determined by homogenizing the muscle sample with distilled water at the ratio 1:5 (weight/volume). The homogenate was subjected to pH measurement using pH meter. Moisture, ash, fat and protein contents of muscles were determined according to the method of AOAC (1999). The values were express as % (wet weight basis).

Analysis for total collagen and soluble collagen were conducted as described by Liu *et al.* (1996). Finely ground muscle (1 g) was hydrolyzed with 10 mL of 6 M HCl at 110°C for 24 h. The hydrolysate was clarified with activated carbon, filter, neutralized with 10 M and 1 M NaOH and diluted with distilled water to a final volume of 100 mL. The hydroxyproline content in the hydrolysate was determined by the procedure of Bergman and Loxley (1963) and convert to collagen content using the factor 7.25. The collagen content was expressed as milligrams of collagen per gram of muscle. Soluble collagen was extracted according to the method of Liu *et al.* (1996). Muscle sample (2 g) were homogenized with 8 mL of 25% Ringer's solution. The homogenates were heated for 70 min at 77°C and centrifuged for 30 min at 2.300×g at 4°C. The extraction was repeated twice. Supernatants obtained were combined. The sediments and supernatants were hydrolyzed with 6 M HCl at 110°C for 24 h. The collagen content of the sediments and supernatant were determined as described previously. The amount of heat-soluble collagen was express as a percentage of the total collagen (collagen content in sediment plus that in the supernatant).

Sensory evaluation: Sensory evaluation was carried out by thirty panelists comprising post-graduate students and technicians from the Department of Food Technology, Prince of Songkla University. The panelists evaluated the preferences in colour, toughness and juiciness of each sample using a nine-point hedonic scale, ranging from 1-dislike extremely to 9 like extremely.

Statistical analysis: Data were evaluated statistically using the SPSS 11.0 computer program. A one-way ANOVA was used to analyze the effects of variables on chemical and physical properties. Significant differences between treatment means were analyzed by Duncan's Multiple Range Test (DMRT) (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Chemical compositions: The proximate composition of spent hen, Thai indigenous chicken and broiler pectoralis and biceps femoris muscles are presented in Table 1. Thai indigenous chicken muscles contained the highest protein and fat but the lowest in ash content, compared to spent hen and broiler ($p<0.05$). Pectoralis muscle showed higher protein content than biceps femoris muscle in all breeds. Protein and fat content of Thai indigenous chicken muscles found in this study were higher compared to previous study by Wattanachant *et al.* (2004). This is probably due to the difference in raising system. Difference proximate compositions in chicken muscles were governed by many factors including age, species, breeds, growth stage and rearing system (Smith *et al.*, 1993; Noppawan *et al.*, 1998; Ding *et al.*, 1999; Van Marle-Koster and Webb, 2000; Wattanachant *et al.*, 2004).

Thai indigenous chicken and spent hen muscles contained higher total collagen but low soluble collagen than those of broiler muscles ($p<0.05$). Differences in the collagen contents among three breeds could be attributed to differences in the age of the bird at slaughter as well as

Table 1: Chemical properties of raw chicken muscles from Thai indigenous chicken, spent hen and broiler

	Breed		
Properties	Indigenous	Spent hen	Broiler
Pectoralis major			
Protein (%)	23.05±0.21^{a}	20.34±0.72^{b}	21.02±0.31^{b}
Fat (%)	2.88±0.26^{a}	1.64±0.18^{b}	1.33±0.21^{b}
Ash (%)	0.60±0.65^{b}	0.19±0.84^{a}	1.44±0.30^{b}
Moisture (%)	74.39±0.41^{b}	74.83±0.15^{b}	76.62±0.37^{a}
Total collagen	7.27±1.14^{a}	7.47±2.79^{a}	3.93±1.69^{b}
(mg g^{-1} muscle)	25.15±0.43^{ab}	19.14±0.48^{b}	29.36±0.87^{a}
Soluble collagen			
(% of total collagen)			
Biceps femoris			
Protein (%)	17.43±0.44^{a}	16.44±0.65^{b}	16.98±0.32^{b}
Fat (%)	1.14±0.47^{a}	1.28±0.35^{a}	0.51±0.14^{b}
Ash (%)	0.75±0.03^{b}	1.29±1.60^{a}	1.43±1.34^{a}
Moisture (%)	80.82±0.71^{a}	79.42±0.81^{a}	77.30±0.66^{b}
Total collagen			
(mg g^{-1} muscle)	10.33±0.98^{b}	13.11±1.77^{a}	9.59±1.87^{b}
Soluble collagen			
(% of total collagen)	19.17±2.84^{b}	16.02±2.45^{b}	31.61±1.98^{a}

$^{a-c}$Means with differing superscripts in the same row are significantly different ($p<0.05$) n = 10 (5 birds×2 determinations)

their intrinsic property. It has also been shown that the heat solubility of collagen decreases with increase collagen cross-linking and cross-linking increases as animal ages (Dawson *et al*., 1991).

Physical properties: Physical properties of all chicken breeds are shown in Table 2. The shear force values of the indigenous chicken and spent hen muscles were significantly higher than broiler muscles. The biceps femoris muscle has been reported to be tougher than pectoralis muscle, which is concomitant with shear value found in this study (Liu *et al*., 1996; Wattanachant *et al*., 2004). The highest cooking loss was found in spent hen biceps femoris muscle. This is probably related to the difference in content of collagen between chicken breed and age slaughter. Thai indigenous chicken and spent hen pectoralis muscle had higher L* and b* value than broiler pectoralis muscle ($p<0.05$). However, the biceps femoris muscle of spent hen had less a* value than the others. This result was probably related to significant difference in muscle pH between the breeds. Muscle pH and meat colour are highly correlated. Higher muscle pH is associated with darker meat than that of lower pH (Allen *et al*., 1998; Fletcher, 1999a, b). The high ultimate pH in broiler muscles especially in biceps femoris muscle has been reported by Wattanachant *et al*. (2004).

Microstructure of muscles: The results of quantitative structural measurements of raw Thai indigenous, spent hen and broiler chicken pectoralis and biceps femoris muscles are presented in Table 2. The means of sarcomere lengths of the raw muscles from three breeds were significant difference ($p<0.05$) in ranges of 1.55-1.62 μm for pectoralis muscle and 1.53-1.64 μm for biceps femoris muscle. Biceps femoris muscle of indigenous chicken had the shortest sarcomere length compared to those of the others ($p<0.05$). The sarcomere length of both muscle types was in range 1.56-1.64 for Thai indigenous chicken and broiler muscles have been reported by Wattanachant *et al*. (2005).

The fiber diameter of spent hen muscles was larger than Thai indigenous and broiler chicken muscles, respectively ($p<0.05$). Fiber diameter of pectoralis muscle from Thai indigenous chicken and spent hen was larger than the fiber diameter of biceps femoris muscles while opposite result were obtained from the broiler. The average diameter of chicken muscle white fiber has been reported to be 38-46 μm (Smith and Fletcher, 1988) and 26-28 μm (Wattanachant *et al*., 2005). These differences in muscle fiber diameter were possibly due to the differences in age, rate of rigor on set and degree of sarcomere shortening (Smith and Fletcher, 1988).

Table 2: Physical properties of raw chicken muscles from Thai indigenous chicken, spent hen and broiler

	Breed		
Properties	Indigenous	Spent hen	Broiler
Pectoralis major			
Cooking loss (%)	25.84±2.78^{a}	24.07±2.59^{a}	20.39±1.42^{b}
Shear force (kg)	2.28±0.49^{b}	3.14±1.19^{a}	1.59±0.17^{c}
pH	5.93±0.01^{c}	6.05±0.02^{b}	6.23±0.01^{a}
Color			
L*	59.47±2.62^{a}	47.79±3.41^{b}	42.48±3.49^{c}
a*	-1.20±0.41^{b}	-0.73±1.68^{b}	1.44±1.45^{a}
b*	9.10±1.48^{a}	7.74±2.73^{a}	9.43±1.75^{a}
Sarcomere length (μm)	1.58±0.66^{b}	1.62±0.14^{a}	1.55±0.88^{b}
Fiber diameter (μm)	16.10±1.83^{b}	18.74±3.87^{a}	16.49±1.86^{b}
Biceps femoris			
Cooking loss (%)	19.66±2.40^{b}	34.91±1.50^{a}	18.59±2.84^{b}
Shear force (kg)	6.31±1.56^{a}	7.24±1.50^{a}	3.99±1.03^{b}
pH	6.06±0.06^{b}	6.22±0.07^{a}	6.25±0.02^{a}
Color			
L*	48.54±2.86^{a}	48.13±4.01^{a}	43.84±2.93^{b}
a*	0.16±1.20^{a}	-0.77±1.11^{a}	0.09±0.63^{a}
b*	5.29±1.83^{a}	5.70±2.44^{a}	6.35±1.64^{a}
Sarcomere length (μm)	1.53±0.16^{b}	1.64±0.93^{a}	1.61±0.13^{a}
Fiber diameter (μm)	19.50±1.66^{b}	21.29±2.86^{a}	14.92±1.57^{c}

$^{a-c}$Means with differing superscripts in the same row are significantly different ($p<0.05$); n = 10 (5 birds×2 determinations) for cooking loss, shear and pH; n = 20 (5 birds×4 determinations) for color; n = 150 (5 birds ×30 determinations) for sarcomere length and fiber diameter

Effect of heating under Tom Yum soup condition: Changes of chicken muscle after heating in Tom Yum soup are shown in Table 3. The pH of all muscles was reduced to 5.0-5.6 after heating in acid condition of the soup. This pH range closed to pI of chicken muscle resulting in denaturation of muscle protein leading to increment of cooking loss. The cooked broiler muscle pH was significantly higher than the others might be due to its muscle protein was higher in buffering capacity. The cooking loss in spent hen, indigenous chicken and broiler pectoralis muscles were not significantly different. The highest cooking loss was found in spent hen biceps femoris muscle ($p<0.05$). This result related to the lowest protein content in this muscle with low water holding ability. In addition this may probably related to the difference in content of crosslinked collagen between chicken breeds and ages at slaughter. For the older spent hen, the more highly crosslinked collagen remained insoluble and shrank during heat treatment and effectively squeezed the acid-heat denatured myofibrillar gel result in high cooking loss. The colour L*, a* and b* value of all chicken muscles increased after cooking in acid condition of Tom Yum soup. The L* value of cooked pectoralis muscle was not different among breeds ($p>0.05$).

Collagen content in meat related to toughness (Dawson *et al*., 1991). Heated spent hen muscles contained the highest total collagen but the lowest

Table 3: Physical and chemical properties of Thai indigenous chicken, spent hen and broiler muscles after heating in Tom Yum soup condition

	Breed		
Properties	Indigenous	Spent hen	Broiler
Pectoralis major			
Total collagen			
(mg g^{-1} muscle)^{ns}	5.02±0.10	5.30±1.19	4.42±0.61
Soluble collagen			
(% of total collagen)	44.62±1.21^{b}	27.74±1.35^{c}	52.49±1.33^{a}
Shear force (kg)	2.65±1.73^{a}	2.35±0.38^{a}	1.09±0.19^{b}
Cooking loss (%)^{ns}	32.25±1.97	34.95±2.35	37.67±8.50
pH of muscle	5.04±0.04^{b}	5.02±0.08^{b}	5.50±0.15^{a}
Cut out pH	5.18±0.01^{c}	5.33±0.04^{b}	5.53±0.04^{a}
Color			
L* ^{ns}	69.65±3.71	70.05±2.82	70.02±2.47
a*	1.67±0.33^{a}	1.05±0.24^{b}	1.63±0.30^{a}
b*	19.25±1.78^{ab}	19.41±1.19^{a}	18.33±0.99^{b}
Biceps femoris			
Total collagen			
(mg g^{-1} muscle)	12.98±0.98^{b}	17.88±1.60^{a}	7.71±0.15^{c}
Soluble collagen			
(% of total collagen)	31.89±1.07^{b}	11.41±1.78^{c}	39.23±1.10^{a}
Shear force (kg)	4.16±0.98^{a}	4.10±0.85^{a}	1.45±0.53^{b}
Cooking loss (%)	36.75±2.02^{a}	41.39±1.52^{a}	27.78±0.36^{b}
pH of muscle	5.27±0.08^{ab}	5.22±0.20^{b}	
5.50±0.27^{a}Cut out pH	5.36±0.03^{b}	5.36±0.12^{b}	5.64±0.03^{a}
Color			
L*	61.83±3.28^{b}	62.28±4.59^{b}	66.63±2.04^{a}
a*	1.54±0.34^{a}	1.04±0.54^{b}	1.76±0.29^{a}
b*	14.63±0.86^{b}	16.69±1.47^{a}	16.37±1.35^{a}

$^{a-c}$Means with differing superscripts in the same row are significantly different ($p<0.05$); ^{ns} non significant difference ($p>0.05$); n = 10 (5 birds×2 determinations) for chemical and physical analyses except n = 20 (5 birds×4 determinations) for color determination

soluble collagen ($p<0.05$). This resulted in the higher shear value in spent hen muscles compared to those of the broiler ($p<0.05$). Heating in Tom Yum soup condition increased soluble collagen content in pectoralis muscle of broiler, Thai indigenous chicken and spent hen for 78, 70 and 40%, respectively. The difference in the amount of soluble collagen among breeds might be due to difference in crosslinked collagen, which are related to the age of the birds. The heat-solubility of collagen decrease with increased collagen crosslinking and crosslinking increases with animal age (Foegeding and Lanier, 1996; Pearson and Young, 1989). The different result among breeds in this study are in agreement with Wattanachant *et al.* (2005a) who found that Thai indigenous chicken muscles had soluble collagen contents less than broiler muscles after heating at 50-80°C. The soluble collagen of cooked broiler and spent hen found in this study was much higher than those reported by Dawson *et al.* (1991); 28.73% for cooked broiler and 17.21% for cooked hen. This is probably due to the acid solution of Tom Yum soup could solubilize the crosslinked collagen resulting in more soluble collagen after cooking. The shear force values of spent hen and Thai indigenous chicken muscle after heating in Tom Yum soup were not significantly different and very much

Table 4: Color of thermal processed spent hen muscles in Tom Yum soup

Muscle	Temperature (°C)	L*	a*	b*
Pectoralis m.	116	64.43±3.99^{c}	1.43±042^{a}	17.99±2.23^{b}
	121	74.60±3.14^{a}	0.59±0.47^{b}	19.17±1.73^{a}
Biceps femoris	116	67.26±2.16^{b}	1.56±0.38^{a}	16.46±1.23^{c}
	121	67.09±2.96^{b}	1.49±0.38^{a}	14.97±1.20^{da-d}

Means with differing superscripts in the same columns are significantly different ($p<0.05$); n = 20

Table 5: Shear force value of thermal processed spent hen muscles in Tom Yum soup

Muscle	Temperature (°C)	Shear force (kg)^{ns}
Pectoralis major	116	3.35±0.71
	121	4.36±1.33
Biceps femoris	116	4.47±0.77
	121	4.68±1.78

^{ns}Non significant difference ($p>0.05$); n = 10

higher than the broiler muscles. However, the soluble collagen content of spent hen muscles was still high after heating. This was probably due to the high content in crosslinked collagen of this meat. Therefore, spent hen meat was selected for thermal Tom Yum chicken processing in further study.

Effect of thermal processing temperatures on properties of Tom Yum spent hen: The effects of thermal processing temperatures at 116 and 121°C on the colour of pectoralis and biceps femoris muscle of spent hen are shown in Table 4. The higher processing temperature caused lighter and less red pectoralis muscle than the lower temperature ($p<0.05$). There were no significant differences on L* and a* values of biceps femoris muscle processed at 116 and 121°C ($p<0.05$). However, b* value of this muscle was decreased when processed with higher temperature. Difference results were obtained from pectoralis muscle. This muscle became lighter and more yellow after processing with higher temperature (121°C) compared to the lower temperature (116°C).

The shear force values of the spent hen pectoralis and biceps femoris muscles processed in retort pouch Tom Yum soup at 116 and 121°C are shown in Table 5. The shear force values were no difference between muscles processed by both thermal temperatures. However, biceps femoris muscle had higher shear values than pectoralis muscle. The shear value of chicken muscles processed at the higher processing temperature also had higher shear values than meat processed at the lower temperature. This is may cause by the heat denaturation of myofibrillar protein and probably connected with gelatinization and loss of intramuscular collagen (Voller-Resonover *et al.*, 1997; Palka, 1999).

Table 6 shows total collagen and heat soluble collagen of thermal processed spent hen chicken muscles. Pectoralis and biceps femoris muscle processed with both temperatures had difference in soluble collagen contents

Table 6: Total collagen and heat soluble collagen of thermal processed spent hen muscles in Tom Yum soup

Muscle	Temperature (°C)	Total collagen[ns] (mg g^{-1} muscle)	Heat soluble collagen (% of total collagen)
Pectoralis	116	5.73±0.94	34.19±2.05[a]
major	121	6.18±1.33	21.67±0.80[b]
Biceps	116	10.76±3.55	32.43±1.78[a]
femoris	121	11.13±1.26	18.03±2.22[b]

[a-b]Means with differing superscripts in the same columns are significantly different ($p<0.05$); [ns]Non significant difference ($p>0.05$); n = 3

Table 7: Sensory evaluation of thermal processed spent hen muscles in Tom Yum soup

Muscle	Temperature (°C)	Colour[ns]	Toughness[ns]	Juiciness[ns]
Pectoralis major	116	6.63±1.10	5.13±1.57	4.60±1.59
	121	6.50±1.14	5.23±1.72	5.23±1.50
Biceps femoris	116	5.93±1.39	5.57±2.05	5.47±1.87
	121	6.07±1.76	6.00±1.89	5.63±2.01

[ns] Non significant difference ($p>0.05$); n = 30

($p<0.05$). The lower processing temperature increased the solubilization of collagen compared to the higher processing temperature of both spent hen chicken muscles. This is probably due to the lower processing temperature had the longer exposure time for equivalent to Fo values. The longer time to heat allowed for greater collagen solublization, resulting in tenderization of the meat. This result was in agreement with Voller-Resonover *et al.* (1997) in which 115.6°C heat processing solubilized collagen to greater degree than 145°C under equivalent Fo thermal treatments.

The sensory evaluation of the spent hen muscle processed in Tom Yum soup at 116 and 121°C is presented in Table 7. No significant difference for all sensory characteristics were observed between chicken muscles processed with both temperatures in Tom Yum soup ($p>0.05$). However, unacceptable results of texture characteristics including toughening, drying and loss of particular shape were observed in pectoralis muscle related to lower preference scores on toughness and juiciness.

CONCLUSION

Meat obtained from different chicken breeds which consumed at different ages had differences in chemical compositions leading to difference in properties of their meat. In raw meat, both breast and thigh muscles from spent hen were the most toughness compared to Thai indigenous and broiler chicken muscles. Heating in Tom Yum soup reduced shear values of biceps femoris muscles from all chicken breeds but had no influence on pectoralis muscles. Heating in Tom Yum soup could increase heat soluble collagen of muscles 78% for broiler, 70% for Thai indigenous chicken and 44% for spent hen. Shear values of cooked spent hen and indigenous chicken muscles were not different and much higher than broiler muscles. Thermal process at high temperature (121°C) caused lighter and more yellowness in pectoralis spent hen muscle compared to lower temperature (116°C). Thermal process at lower temperature (116°C) increased more soluble collagen of spent hen muscle than the higher temperature (121°C) equivalent to the same F_o value. Sensory evaluation of spent hen thermal process with high temperature at 116 and 121°C cause no differences in spent hen muscle. However, biceps femoris muscle was obtained more preference on texture from the panelists. Therefore, thigh muscle of spent hen could be the alternative material suitable for retort pouch Tom Yum soup product.

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