Philipp J Vet Anim Sci 2016, 42 (2): 143-150

COMPARATIVE EVALUATION OF CARCASS AND MEAT CHARACTERISTICS, AND CONSUMER PREFERENCE OF FREE-RANGED AND CONVENTIONALLY-RAISED CHICKENS

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ABSTRACT

The carcass and meat characteristics of and consumer preference for free-ranged Banaba native chickens, free-ranged commercial broiler chickens, and conventionally-raised commercial broiler chickens were compared. The conventionally-raised commercial broiler chickens had the highest (P<0.05) percent breast meat, CIE L* values, and crude fat, while free-ranged chickens had the highest percent ash. Overall, Banaba native chickens grown under free-ranged system produced carcasses that are comparable in meat quality and lean color with the commercial broiler chickens grown under both free-ranged and conventional production systems. However, the free-ranged Banaba native chicken meat was the least preferred by the consumers.

Keywords: broiler chickens, chicken meat, carcasses, consumer preferences, free-range husbandry

INTRODUCTION

There are several factors affecting the quality of poultry meat such as genetics, environmental and pre-slaughter factors and postmortem changes of muscle (Tougan *et al*., 2013). For non-genetic factors, production system is one which has considerable effect on meat quality (Bogosavljevic-Boskovic *et al*., 2006). Chickens are traditionally raised under extensive farming or free-ranged production system, wherein they can roam freely in their natural environment. At present, majority of the population of broiler chickens are raised under confinement system. However, some animal welfare problems are being associated with this production system. Animal welfare is increasingly viewed as a factor affecting the quality of animal products while being an important tool of marketing strategy.

Free-ranged production system is believed to improve the welfare of the animal by allowing the chickens to express their natural behavior due to lower stocking density, and access to natural lighting. It is also believed to be an important contributing factor in the production of higher quality chicken meat (Angood *et al*., 2008; Pavlovski *et al*., 2009). Furthermore, consumers believe that the meat of free-ranged chickens is healthier compared to chickens raised under the intensive production system (Fanatico *et al*., 2006a). It is known that fast-growing broiler chickens have not adapted to extensive management systems, but in USA and Poland they are commonly raised under extensive conditions for economic reasons (Castellini *et al*, 2006; Fanatico *et al*, 2007). On the other hand, Philippine native chickens are adapted to scavenge-based system which is synonymous to the free-range production system. Native chickens are increasingly preferred by consumers because of its unique flavor, its suitability to native dishes and as an alternative for commercial chicken meat (Lambio, 2010).

Considering the aforementioned, this research aimed to compare the carcass and meat characteristics, and consumer preference of free-ranged Philippine native chicken, free-ranged commercial broiler strain, and conventionally-raised commercial broiler.

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MATERIALS AND METHODS

Eight 16-week-old chickens belonging to two chicken strains (Banaba native chicken and commercial broiler chicken) were sourced from the University Animal Farm (UAF), Animal and Dairy Sciences Cluster, College of Agriculture, University of the Philippines Los Baños, located in Putho-Tuntungin, Los Baños, Laguna. After brooding for 30 days, the chickens were then hardened for 15 days, and fed with commercial feeds. These chicken strains were grown from 45 days up to sixteen weeks under free-range system at the UAF. Only female chickens were selected for this study due to availability at the time of sampling. The four conventionally-raised commercial broiler carcasses that were used were bought from the local market located in Mayondon, Los Baños, Laguna.

The experiment was done following Completely Randomized Design with free-ranged Banaba native chicken, free-ranged commercial broiler and conventionally-grown commercial broiler as experimental treatments and were replicated four times. The free-ranged chickens were fasted for 12 hours and dressed at the Poultry line of the ADSC slaughterhouse complex following the standard procedures for poultry dressing.

The chicken carcasses were fabricated following the method described by Bogosavljevic-Boskovic *et al.* (2006). Leg and breast cut yield were computed. The legs and breasts were separated into lean, fat and skin, and bone components. The percentage of each component was determined.

Skin and lean color were measured on the left breast part using the CIE *L** (lightness), *a** (redness), and *b** (yellowness) values of the chromameter (Capsure™ Pantone® X-Rite, USA).

Gastrocnemius muscle was separated from the lean tissue sample of the right leg. The muscle was sliced thinly and soaked in a fixative solution (900mL dH_2O, 100 mL 40% formalin, 20 g $NaCH_3COO$, and 9 g NaCl) for 24 h. A single fasciculus from the *Gastrocnemius* was placed on a petri dish with 10 mL physiological saline solution (100 mL dH_2O and 8.5 g NaCl). After teasing the muscle, a single muscle fiber was placed on a glass slide. The muscle fiber diameter (MFD) measured in micrometer (µm) was determined using the DinoXcope (Big C Dino-Lite Digital Microscope, USA).

Lean tissue samples from the left breast were steamed for 30 minutes, and were cut approximately 1.75x0.7x0.5 inches. Meat tenderness was measured as shear force or maximum force (N) perpendicular to the fibers using a Warner-Bratzler machine (The G-R Elec MFG, USA).

Water-holding capacity (WHC) was determined based on the volume of free-water squeezed out from the lean tissue sample of the right breast using the Grau and Hamm (1953) filter paper press method. A meat sample weighing 0.4-0.6 g was subjected to 500 psi for 1 min using a Hydraulic Carver Press (Fred S Carver, Inc, USA).

The moisture, crude fat, crude protein, and ash content of the right breast were analyzed using standard procedures of the AOAC (1995).

Carcass meats from the different treatments were boiled separately for 30 min. After cooking, the breast muscles were immediately separated from the rest of the carcass. The separated breast muscles were cut into one inch cubes, and used for the preference test.

The 50 consumers were randomly chosen from the walk-in customers of the dairy bar at ADSC, CA, UPLB. The meat samples were judged using a 7-point hedonic scale, with 1 as least preferred and 7 as most preferred, with 5 attributes being tested: color, tenderness, juiciness, flavor, and overall preference.

All data were analyzed using the completely randomized design procedure in the Statistical Tool for Agricultural Research v.2.0 (STAR v.2.0) (IRRI, 2014). Differences among mean values were compared using the LSD and significance is reported at the $P<0.05$ level.

RESULTS AND DISCUSSIONS

Carcass Characteristics

The carcass weight, cut-up yield, carcass composition, skin and lean color are summarized in Table 1. The average carcass weights of the conventionally-raised commercial broiler, free-ranged commercial broiler and free-ranged native chicken were 1196.67 g, 496.67 g, and 676.67 g, respectively.

Cut-up yield

The free-range system offers freedom for the chickens to exercise in the paddock, which might improve the development of leg muscles. However, there were no significant differences in the leg yield among treatments ($P>0.05$). The result suggests that the leg muscle development of the chickens is not affected by the force motor activity in the free-range system which was also observed by Bogosavljevic-Boskovic *et al.* (2006), but these were in contrast with the observations of Castellini *et al*. (2002) that Ross chickens having outdoor access have higher leg yield. The increased leg yield can be attributed to either or both muscle fiber hypertrophy and hyperplasia.

Conventionally-raised commercial broiler has the highest breast yield ($P<0.05$) and lowest was the free-ranged commercial broiler. Conventionally-raised commercial broilers were expected to achieve the highest breast yield since they have reached their full growth potential to satisfy consumer demands and to achieve maximum profitability

Table 1. Carcass characteristics of free-ranged Banaba native chicken, free-ranged broiler and conventionally-raised commercial broiler.

Characteristics	Chicken			P-value
	Free-ranged Banaba Native Chicken	Free-ranged commercial Broiler	Conventionally-raised commercial Broiler	
Carcass weight (g)	676.67	496.67	1196.67	-
Cut-up part yield (%)				
Leg	29.84	32.56	28.24	0.1519
Breast	26.12^{b}	23.34^{c}	36.14^{a}	<0.001
Lean (%)	77.08^{a}	68.49^{b}	76.27^{a}	0.0003
Bone (%)	14.63^{b}	23.13^{a}	12.03 ^{b}	0.0023
Fat and Skin (%)	8.28	8.37	11.60	0.1057
Skin Color				
L*	64.19^{b}	62.22^{b}	70.78^{a}	0.0038
a*	-0.22^{a}	0.42^{a}	-3.48^{b}	0.0045
b*	25.38^{a}	13.38^{b}	5.34^{c}	0.0003
Lean Color				
L*	49.5	55.57	52.39	0.2833
a*	1.12	1.98	-1.32	0.0828
b*	10.16	8.86	9.13	0.8683

Data within the same row with different superscripts are significantly different ($P<0.05$)
CIE: L* – lightness; a* – redness; b* - yellowness

(Macrae *et al*., 2007). However, the strains indigenous to the Philippines are not primarily selected for meat yield capacity but for adaptation under extensive production system and for intense meat flavor. According to Lei and Van Beek (1997) and Lewis, *et al*. *(*1997), increased physical activity could increase the percentage of breast meat; however, this was not observed in the free-ranged commercial broiler strains. Under the free-range system, commercial broilers decreased in breast yield because it is not adapted to this type of production system.

Carcass composition

The percent lean of the free-ranged commercial broiler was lower (P<0.05) compared to the conventionally-raised commercial broiler and free-ranged native chicken. Commercial broilers are fast-growing chickens but it needs to be supported with high quality feeds and supplements in order to achieve its full genetic potential. Under the free-range system, lean accretion in the free-ranged broiler is impaired (Bogosavljevic-Boskovic *et al*., 2006) because the full potential of broiler is not realized under this type of production system. The performance of the free-ranged native chicken and conventionally-raised commercial broiler was comparable in terms of percent lean because the two chickens were both raised under their optimum production system.

The high percent bone (P<0.05) observed in the free-ranged commercial broiler can be explained by either impaired lean accretion or increased bone development due to exercise (Mikulski *et al.,* 2011).

There were no significant differences (P>0.05) observed in the percent skin and fat among chicken groups.

Color

Color is one of the first characteristics noticed by consumers when buying meat products. In markets, where carcasses are often marketed whole, the color of the skin plays a particularly important role (Fanatico *et al*., 2007). The differences in skin color can be explained by the differences in genetics, feeds, and metabolism. Differences (P<0.05) in skin color were observed among the treatments. While the free-ranged chickens groups had the lowest lightness value, it also had the highest redness values. Furthermore, highest yellowness values were observed in the free-ranged native chicken. The differences in yellowness of skin color is dependent on the genetic ability of the bird to produce melanin pigments in the dermis and epidermis, as well as to absorb and deposit carotenoid pigments in the epidermis (Fletcher, 2000). The greater yellowness of the free-ranged native chicken could be a result of their intake of pasture sward, which is a source of carotenoid. On the other hand, the carcass of the native chickens are known for being highly pigmented and this was evident in the study where the skin of the free-ranged native chicken had higher *b** values (P<0.05) than the free-ranged commercial broiler.

Lean color influences retail purchasing decisions more than any other quality factor because consumers use discoloration as an indicator of spoilage and shelf life. Myoglobin content is a major factor contributing to lean color and is dependent on species, muscle, and age of bird (Fletcher, 2002). Outdoor access and associated exercise could impact muscle fibers and color. However, according to Fanatico *et al.* (2007), access to free range does not affect the carcass color of the chickens, which is same with the result of this study (P>0.05) using breast meat of the chickens.

Meat Characteristics

Meat quality is affected by the factors: genetics, nutrition, environment, and additives. Muscle fiber diameter (MFD), meat tenderness, water-holding capacity (WHC) and proximate composition are measures of meat quality examined in this study. The results are presented in Table 2.

A number of factors such as age, sex, strain, and environment have been shown to affect meat tenderness, as well as muscle fiber diameter. The MFD and meat tenderness

Table 2. Meat characteristics of free-ranged Banaba native chicken, free-ranged broiler and conventionally-raised commercial broiler.

Characteristics	Chicken			P-value
	Free-ranged Banaba native chicken	Free-ranged commercial broiler	Conventionally-raised commercial broiler	
MFD (µm)	57.59	54.00	46.82	0.2464
Tenderness (N)	18.33	17.86	15.94	0.0925
WHC (% free water)	15.5	20.17	20.92	0.1883

Data within the same row with different superscripts are significantly different (P<0.05)
MFD – muscle fiber diameter; WHC – water holding capacity

are interrelated traits and a positive relationship between MFD and meat toughness has been reported (Tang, et al., 2009). Increase in physical activity can increase MFD and consequently make the meat tougher. However, there were no significant differences (P>0.05) observed in the MFD and meat tenderness between the treatments. Likewise, Fanatico *et al.* (2007) found no effect of the rearing system on shear force value of the muscles of fast-growing chickens.

The WHC is important in whole meat and processed meat products. In this study, no significant difference was observed in the WHC among the groups. This result is similar with the study of Brown *et al*. (2008), where they found no differences in breast meat WHC between standard and free-range chickens. The ultimate pH (pHu) is known to influence the structure of myofibrils and consequently the water holding capacity and the color of the meat. It is well established (Warris, 2000) that shrinkage of the contractile fibers caused by lower pHu reduces the water-binding ability of meat, therefore increasing light scattering. These relationships were observed in the present study where the different chicken groups had no significant differences in the WHC and lean meat color.

Proximate Composition

According to Field (2004), moisture content of meats fluctuate with lipid content, while according to Bull (1951), fat and moisture content are inversely related to each other. The inverse relationship of fat and MC was not observed in the study. While the fat content of conventionally-raised commercial broiler was higher (P<0.05; see Table 3) compared to the free-range chickens, the moisture content among chicken groups did not significantly differ (P>0.05).

The conventionally-raised commercial broiler had the highest crude fat (P<0.05), may be due to the high energy level of the commercial feed coupled with less physical activities under intensive production system, thus promoting lipogenesis. Moreover, the crude fat of free-ranged native chicken were lower (P<0.05) compared to the conventionally-raised commercial broiler. According to Suganthi (2013), the meat of native breeds of chicken have low fat content and are considered as an alternative for consumers preferring low fat meat. On the other hand, the free-ranged commercial broiler had the lowest crude fat. The impaired lipogenesis in the free-ranged commercial broiler can be attributed to the increased physical activity and poor foraging. In general, fat is deposited in the body when there is an excess energy that can be stored.

The amounts of ash in the free-ranged chickens were higher (P<0.05) than that of conventionally-raised commercial broiler. This can be attributed to the composition of food foraged by the free-ranged chickens. Most of the scavenged foodstuff in the unrestricted environment includes stones and soil which are rich in minerals.

Table 3. Proximate Composition of the breast muscle from free-ranged Banaba native chicken, free-ranged broiler and conventionally-raised commercial broiler.

Composition (%)	Chicken			P-value
	Free-ranged Banaba native chicken	Free-ranged commercial broiler	Conventionally-raised commercial broiler	
Moisture (%)	75.88	77.31	77.28	0.2593
Crude Fat (%)	2.58[b]	1.53[c]	3.96[a]	0.0025
Crude Protein (%)	20.00	20.26	19.66	0.8834
Ash (%)	1.41[a]	1.61[a]	0.74[b]	0.0007

Data within the same row with different superscripts are significantly different (P<0.05).

Consumer Preference Test

Consumer preference was conducted using the breast muscles of commercial and free-ranged chickens. There were no significant differences found in the breast meat color (P>0.05; see table 4) among treatments, similar to the results using the chromameter. On the other hand, the most preferred in terms of tenderness and juiciness is meat from the conventionally-raised commercial broiler, while the least preferred is from the free-ranged native chicken. The taste of the meat of commercial broiler was found to be not affected increased physical activity, with no difference found between the conventionally-raised and free-ranged. Among the treatments, the most preferred overall was meat from the conventionally-raised commercial broiler, while the least preferred meat is from the free-ranged native chicken. This result contradicts the result of the study of Lambio *et al*. (2000) which showed that native chickens are the most preferred. These contrasting results may be due to the difference of cooking method, cooking temperature, and cooking time.

Table 4. Consumer preference on free-ranged Banaba native chicken, free-ranged broiler and conventionally-raised commercial broiler.

Attributes	Chicken			P-value
	Free-ranged Banaba native chicken	Free-ranged commercial broiler	Conventionally-raised commercial broiler	
Color	4.92	4.59	5.08	0.2273
Tenderness	3.04[c]	4.94[b]	5.88[a]	<0.0001
Juiciness	3.65[c]	4.71[b]	5.59[a]	<0.0001
Flavor	3.86[b]	4.45[a]	5.00[a]	0.0026
Overall Preference	3.73[c]	4.82[b]	5.61[a]	<0.0001

Data within the same row with different superscripts are significantly different (P<0.05);
Mean consumer scores given by consumer panel on a 7-point hedonic scale: 1-7, least preferred to most preferred.

CONCLUSION

Under the free-ranged system, commercial broilers had lower percent breast, percent lean, and crude fat but had higher percent bone, crude ash and more reddish skin color compared to commercial broiler chickens raised under conventional system. On the other hand, the meat quality and lean color of the free-ranged chickens and conventionally-raised commercial broilers were not different. The consumer preference test revealed that conventionally-raised broilers were the most preferred by consumers, while the least preferred was free-ranged native chicken. It also showed that there was no difference in preference for flavor between free-ranged and conventionally-raised commercial breed, but both were more preferred than native chicken.

ACKNOWLEDGMENT

The authors express their sincere gratitude to the staff of the Animal and Dairy Sciences Cluster and Food Science Cluster for all their help and support during the conduct of the study.

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