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Physico-chemical Composition and Functional Properties of Native Chicken Meats

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Native chicken genetic groups namely Paroakan, Banaba and Joloanon were obtained from BAI/DA station in Tiaong, Quezon. Commercial broiler was used as control. Samples were analyzed for meat yield, pH, and proximate composition, water holding capacity, emulsion activity and emulsion stability. Results were analyzed statistically using Analysis of Variance and Duncan's New Multiple Range Test. There was no significant difference among the meat yields of the different native chicken genetic groups and commercial broiler. Variations in the proximate composition of the different chicken parts were affected by genetic groups. Breast and leg samples from Broiler gave the highest pH. Emulsion activity and emulsion stability of Broiler's breast and leg were significantly higher than those of the different native chicken genetic groups. Emulsion activity of breast from the different native chicken genetic groups was not significantly different. Banaba breast gave higher emulsion stability compared to other native chicken genetic groups. Meat from various genetic groups of native chicken has the potential as a healthy substitute to commercial broiler because it had higher crude protein and lower fat than commercial broiler. However, commercial broiler has better functional properties than native chicken meat because of its significantly higher pH, emulsion activity and emulsion stability.

Key words: Banaba, Broiler, Chicken, Composition, Joloanon, Paraokan

INTRODUCTION

Chicken meat is one of the main sources of animal protein aside from beef and pork. Many consumers prefer chicken meat because it is cheaper per kilo than beef and pork. Commercial broilers are the main sources of chicken meat in the country. Domestic consumption of broiler chicken meat increased from 893,000 metric tons in 2011 to 1,105,000 metric tons in 2015 (USDA 2016). There is insufficient supply of chicken meat in our country as indicated by the increased chicken meat importation from 146,000 metric tons in 2011 to 210,000 metric tons in 2015 (USDA 2016). Chicken meat importation can be reduced by evaluating the potential of other sources of poultry meats such as native chickens.

Although native chickens are consumed as food in this country, the prospective of the native chicken meat as a substitute for broilers on the basis of its food quality is a domain to be explored. The consumption of native chicken meat can be a promising avenue in exploiting the current band wagon of utilizing organically grown agricultural products. Furthermore, there is a big export potential for organic chicken in US and Europe because health

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conscious consumers are demanding organic chicken meat (Cobanoglu et al. 2014). This study evaluated the physico-chemical composition and functional properties of native chicken meat and commercial broiler. Specifically, it determined the proximate composition, meat to bone ratio, water holding capacity, emulsion capacity, emulsion stability and pH of meats from various native chicken genetic groups and broiler produced during wet season.

MATERIALS AND METHODS

Determination of physicochemical composition of native chicken meat

Sample preparation for analysis

Native chicken genetic groups namely Paroakan, Banaba and Joloanon were purchased from BAI/DA station in Tiaong, Quezon. The native chickens were fed with madre de agua (*Tricahantera gigantea*) and grown free range. The average weight of the live chickens were Paraokan (1.2 kg), Banaba (1.01 kg) and Joloanon (1.2 kg). Three chickens were used per genetic group. The age of the chickens was not determined during purchase. The native chickens were manually slaughtered at the source to prevent stress. The chicken meats were packed in PE bags and placed in Styrofoam with ice during transport to the laboratory. The chicken meats were refrigerated (5-7ºC) overnight. The chickens were cut and segregated into, meat skin and bones and frozen (-10ºC).

The commercial broilers were bought from a public market vendor. The parentage of the commercial chickens was not determined. The chickens were grown in conventional system. The average weight of the three commercial broilers was 1.3 kg prior to slaughter. The age of the chickens was not determined during purchase. The chickens were slaughtered manually at the Food Science Cluster Pilot Plant. The slaughtered chickens were packed in PE bags and refrigerated (5-7ºC) overnight. The chickens were cut and segregated into, meat skin and bones and stored in the freezer (-10ºC).

Meat yield determination

The weight of the different parts of the chickens were determined and recorded. Meat yield was determined using the equation:

$$\text{Meat Yield (\%)} = \frac{\text{Wt of Meat}}{\text{Wt of Bones} + \text{Wt of Meat}} \quad X \ 100$$

Determination of proximate composition

Moisture content (oven method), ash (furnace), crude protein (Kjeldahl method) and crude fat (soxhlet method) were determined using the AOAC official methods of analysis (AOAC 2003).

Determination of functional properties

pH determination

The pH of the frozen chicken meat samples were determined after thawing at (5-7ºC) overnight. Milwaukee pH pen was used to determine the pH of the chicken meat samples. pH was determined using AOAC official methods (AOAC 2003).

Water holding capacity

Water holding capacity was determined by Carver press method (Argañosa 1998). In the process 0.4 to 0.6 mg meat sample was placed in Whatman No.1 filter paper which was then inserted between Plexiglass plates. The meat was pressed for 1 min at 500 psi. After pressing the total area and the meat area was determined using plastic grid. The percent free water and percent bound water were determined.

Emulsion activity (EA) and emulsion stability (ES)

The procedure for both emulsion activity and emulsion stability tests were based on the work of Volkert and Klein (1979) with some modifications. Emulsion activity (EA) was expressed as the percent (%) of the total mixture emulsified. Emulsion stability (ES) was determined by preparing the emulsion according to EA procedure then heating the emulsion at 80ºC for 30 minutes then cooling in a water bath (24-25ºC) for 30 min before centrifugation. Emulsion stability (ES) is expressed as the percent of the total volume remaining emulsified after heating.

Statistical analysis

Data were analyzed using analysis of variance (ANOVA) and DMRT using Statistical Analysis System (SAS v 9.1)

RESULTS AND DISCUSSION

Meat Yield (%)

The meat yield was highest in Broiler meat and lowest in Banaba meat (Table 1). Native chicken meats had lower meat yields because these have higher bone content than commercial broiler. Native chickens have more bones as an adaptive mechanism for movement and scavenging food in their free range environment (Koster and Webb 2000). Statistically, however, there was no significant difference among meat yields of different native chicken genetic groups and broiler (Table 1).

Table 1. Meat yield of different native chicken genetic groups and broiler.

Genetic Group	Meat Yield (%)
Paraokan	47.40a
Joloanon	38.59a
Banaba	43.80a
Broiler	53.93a

Means in the same column and row followed by the same letter are not significantly different from each other at P<0.05.

Proximate composition of meats from different genetic groups of native chicken

Moisture content

Breast samples from Broiler (78.00%) and Banaba (78.16%) gave significantly highest moisture content while Paroakan (73.84%) have significantly lowest moisture content (Table 3). The moisture content of Broiler and Banaba found in this study were higher than published moisture content of chicken breast which is 75.6% (Abdon et al. 1980). On the other hand, Paraokan had lower moisture content compared to Darag (76%) (Fernandez et al. 2007). Joloanon breast samples (75.26%) had the same value of the breast fillet moisture content (75.26%) as reported by Souza et al. 2011.

Leg samples from Paroakan (73.79%) had significantly lower moisture content compared with Broiler, Banaba and Joloanon. The rest have moisture contents that were not significantly different from each other and ranged from 76.34-77.10%. These values were similar to literature values of chicken leg moisture content of 76.7% (Abdon et al. 1980) 76.7% and 77.15% (Souza et al. 2011). Skin samples from Banaba (70.87%) and Joloanon (69.89%) have the significantly highest moisture content followed by Paroakan (65.19%) and CB (59.63%) had the significantly lowest moisture content.

Ash content

Breast samples from Broiler (1.21%) had highest ash content followed by Joloanon (1.12%) and Paroakan (1.05%) which were not significantly different. Banaba had the lowest value of 0.94% (Table 3). The ash content of the various chicken breast samples in this study were lower than literature value as found by Okarini et al. (2013) for Bali indigenous chicken (1.39%) and broiler breast (1.78%). Leg samples from Joloanon gave significantly lower ash content than B, Paraokan and Banaba. The skin samples have significantly similar ash content.

Fat content

The fat content of breast meat samples from broiler and all native chickens did not differ significantly from each other. The values obtained in this study were lower than the Bali indigenous chicken (1.73%) and broiler breast (4.7%) (Okarini et al. 2013) and Darag (3.7g fat/100g) (Fernandez et al. 2007). The fat content of Paraokan and Joloanon breasts were similar to literature value (1.60%) as reported by Abdon et al. (1980).

Leg samples from broiler gave the highest fat content (4.01%) followed by Joloanon (2.84%) and Paroakan (2.79%) and the least was Banaba (1.60%). The fat content

Table 2. Proximate composition of meats from different native chicken genetic groups and broiler.

Sample	Genetic Group	Moisture (%)	Ash (%)	Crude Fat (%)	Crude Protein (%)
Breast					
	Paraokan	73.84c	1.05b	1.62a	22.20a
	Banaba	78.16a	0.94c	1.30a	19.66b
	Joloanon	75.26b	1.12b	1.61a	21.40a
	Broiler	78.00a	1.21a	1.20a	19.45b
Leg					
	Paraokan	73.79b	1.00a	2.79b	20.69a
	Banaba	77.10a	0.97ab	1.60c	19.55a
	Joloanon	76.34a	0.91b	2.84b	20.25a
	Broiler	76.79a	1.03a	4.01a	17.89b
Skin					
	Paraokan	65.19b	0.60a	17.77b	14.13a
	Banaba	70.87a	0.68a	15.25c	14.04a
	Joloanon	69.89a	0.78a	15.52c	13.40a
	Broiler	59.63c	0.68a	29.78a	10.02b

Means in the same column and body part followed by the same letter are not significantly different at P<0.05.

of the broiler leg was similar to the value reported by Jayasena et al (2013) which ranged from 3.41-4.45%. The fat contents of Joloanon and Paraokan were similar to the value reported by Abdon et al., (1980) which was 2.70%. Skin samples from Broiler still gave the highest fat content (29.28%) while Banaba skin gave the lowest content (15.25%). Based from the data, the fat of chicken was concentrated in the skin. In general native chicken meats had lower fat content than broiler meat because the native chickens were grown free range. The fat was utilized as energy in the unrestricted movements of the chickens. Broiler meat had higher fat content because it underwent the conventional system of growing where there is less physical movement of the chickens.

Crude protein

Crude protein of Paroakan breast (22.20%) and Joloanon breast (21.40%) and were significantly higher than that of Banaba (19.66%) and Broiler (19.45%). Paraokan breast had similar protein content with the Bali indigenous chicken breast (22.32%) (Okarini, et al. 2013) but higher than Darag (20.1g/100g) (Fernandez et al. 2007). Crude protein of the legs of Paraokan was higher than the Korean native chicken (20.10-20.29%) (Jayasena et al. 2013). Leg samples from Broiler (17.89%) had the lowest crude protein when compared to rest of chicken's samples (19.55-20.69%). Likewise, skin samples from broiler had lowest crude protein (10.22%) among the different native chicken genetic groups (13.40-14.1%). Skin samples from broiler had lowest crude protein (10.22%) among the different native chicken genetic groups (13.40-14.1%3).

The high protein content of the meats from various native chicken genetic groups can be due to the diet of the native chickens. The native chickens were fed with madre de agua (*Trichantera gigantean*) leaves. The leaves of madre de agua was reported to contain 18.21% protein (Jaya et al. 2008). Furthermore, the free range management of the native chickens in the farm also contributed to the high protein content of the native chicken meats. Muscles are made up of protein and when these are worked simultaneously there is gain in size and strength. In addition, when muscles are physically active the DNA and RNA are signaled to produce more protein (Whitney and Rolfes 2005).

Functional properties of meats from different native chicken genetic groups and broiler

pH of meat of native chickens and broiler

Breast meat of broiler gave the highest pH (6.12) but it was not significantly different from pH of Banaba (6.04). The pH of broiler breast in this study was within the range of the pH of broiler breast (5.81-6.23) reported by Qiao et al. (2001).

Table 3. pH of breast and leg meats from different native chicken genetic groups and broiler.

Genetic Group	pH	
	Breast	Leg
Paraokan	5.86 c	6.06 b
Banaba	6.04 ab	6.10 b
Joloanon	5.96 bc	6.00 b
Broiler	6.12 a	6.34 a

Means in the same column and body part followed by the same letter are not significantly different at $P<0.05$.

On the other hand, Paroakan breast had the lowest pH (5.86) but it was not significantly different from the pH of Joloanon (5.96). The pH values of Paraokan and Joloanon breasts were similar to the pH of Korean native chicken (5.72-5.99) (Jayasena et al. 2013). According to (Kralik et al. 2014) the normal breast pH is 5.91-6.02 while pH 5.88-5.84 was pale soft exudative chicken breast and pH 6.35-6.4 was dark, firm and dry chicken breast.

The pH of Broiler legs (6.34) was significantly higher than the pH of the native chickens (6.0-6.1). The pH of the native chickens' legs also did not differ significantly from one another. The pH values for the legs of the native chickens were lower than the Korean native chicken legs (6.32-6.33) (Jayasena et al. 2013).

The onset of rigor mortis usually occurs in chicken within 2-4 hrs. In the process, blood circulation stopped, rendering anaerobic condition in the muscle. Glycolysis proceeded under this condition forming lactic acid resulting in decreased pH from 6.5 to 5.8 (Belitz and Grosch 1999). In addition, environmental stress experienced by the chicken prior to slaughter, scalding method and chilling rate also affect the pH of meat. Normal meat has pH of 6.5 one hour after slaughter and it goes down to 5.8 after 24 hrs. Pale soft and exudative meat (PSE) has pH 5.61 one hour after and 5.61 24 hours after slaughter. Dark, firm and dry (DFD) meat has pH of 6.5 one hour after and pH of 6.3 24 hours after slaughter (Belitz and Grosch 1999).

Water holding capacity (WHC)

Water holding capacity is the ability of meat to retain moisture. Moisture is held by proteins to different extent, and the variation in these types of moisture can be classified as free water, bound water and immobilized water. (Huff-Lonergan and Lonergan 2005). Free water is loosely held by capillary forces and easily lost during processing procedures such as cutting, grinding, storage (drip) and cooking, Bound water is the most tightly bound and is not affected by addition of salt or changes in pH. However, bound water is reduced as the meat goes into rigor mortis and when cooked.

Free water

For breast sample, Joloanon gave significantly the highest free water of 20.15% while Paroakan has significantly the lowest free water of 12.06% (Table 4). Banaba and Broiler did not have significantly different free water of 16.62% and 16.09 % respectively. Based on free water, Paroakan had highest water holding capacity since it had the least free water.

For leg part Joloanon's free water was the highest (23.17%) among the chicken samples analyzed (Table 4). Paroakan had significantly the lowest free water valued at 18.19%. Banaba and Broiler had free water values that were not significantly different. Based on free water Paraokan breast and leg meats has the highest potential for processing since it consistently had the lowest free water

Bound water (BW)

For breast portion, BW was significantly highest for Paroakan (88.46%) followed by Banaba (84.18%) and Broiler (83.91%) with BW which were not significantly different from each other. The lowest BW was that of Joloanon (79.67% (Table 4). Among the native chicken meats Paraokan has the potential for meat processing because of its significantly highest BW. This implies that Paraokan has the highest WHC among the meat samples and will have the least processing loss. The values for water holding capacity obtained from this study were higher that the Korean native chicken breast (61.36-62.19%) and thigh (62.29-62.82%) and broiler breast (61.73-62.89%) and broiler thigh (60.54-61.54%) (Jayasena et al. 2013).

Table 4. Water holding capacity of meats from different native chicken genetic groups and broiler.

Sample	Genetic Group	Free Water (%)	Bound Water (%)
Breast			
	Paraokan	12.06c	88.46a
	Banaba	16.62c	84.18b
	Joloanon	20.15a	79.67c
	Broiler	16.09b	83.91b
Leg			
	Paraokan	18.19b	81.81a
	Banaba	22.50ab	76.87a
	Joloanon	23.17a	76.83a
	Broiler	19.58ab	79.39a

Means in the same column and body part followed with the same letter are not significantly different at P<0.05.

Emulsifying properties

Emulsion consists of two immiscible liquid (water and oil) phases forming a colloidal dispersion. Proteins are used in many food systems as emulsion stabilizer or emulsifier. They have the ability to absorb at interfaces, form continuous protein films surrounding lipid droplets and reduced interfacial tension. Emulsifying properties could be expressed as emulsion activity (EA) which is the percentage of the mixture emulsified after blending and incubation at 24-25ºC for 30 min. or as emulsion stability which is the percentage of the mixture emulsified after heating the mixture at 80ºC. Emulsifying property of a material is important functional property of meat especially in preparing meat batters or comminuted meat products.

Emulsion activity (EA)

Commercial broilers and native chicken meats contained moisture, fat and protein which make them potential for the formation of a meat emulsion (Table 2). Native chicken meats had higher crude protein contents than broiler meat implied that more fat globules can be coated. Higher protein content means there is a higher potential to form an emulsion because protein serve as the emulsifier.

For breast portion, Broiler gave the highest emulsion activity (61.41%) while the different native chickens gave lower EA which did not differ from each other (Table 5). For leg portion, Broiler also has the highest EA (55.33%). The EA of the legs of the different native chicken are lower than that of the broiler and were not significantly different from each other. Higher emulsion activity was noted in broiler breast and legs because broiler had the highest pH than native chicken samples (Table 3). At higher pH more protein is extracted, therefore, more protein is available to coat the fat globules. Therefore, broiler meat was more suitable for emulsion formation than native chicken meats.

Emulsion stability (ES)

Broiler breast gave the highest ES (68.53%) followed by Banaba (22.67%) and the least were Joloanon (16.56%) and Paroakan (14.21%) with ES that were not significantly different from each other (Table 5). For leg the ES of broiler was significantly higher (60.51%) than any of the native chicken. The three native chickens have ES that were not significantly different.

Based on the results both Broiler breast and legs have better EA and ES than the native chickens. This could be

Table 5. Emulsion activity and emulsion stability of meats from different native chicken genetic groups and broiler.

Sample	Genetic Group	Emulsion Activity (%Mixture Emulsified)	Emulsion Stability (%Mixture Emulsified After Heating)
Breast			
	Paraokan	17.06b	14.21c
	Banaba	15.16b	22.67b
	Joloanon	15.62b	16.56c
	Broiler	61.41a	68.53a
Leg			
	Paraokan	15.96b	17.36b
	Banaba	13.94b	16.67b
	Joloanon	15.81b	16.63b
	Broiler	55.33a	60.51a

Means in the same column and part followed by the same letter are not significantly different at $P<0.05$.

attributed to the higher pH of broiler meat than the native chicken meats (Table 3). At higher pH more protein is extracted, therefore, more protein is available to coat the fat globules. Furthermore, at higher pH values more stable emulsions are formed because at higher pH meat has higher water binding ability. Another reason is due to maturity of chicken. All the native chickens are older than the broiler which may hinder the extraction of meat proteins due to more ligaments and connective tissues present. The formation of high amount of connective tissues in native chicken meats was due to the unrestricted physical activities of the native chickens in the free range environment. Broiler chicken meat was more suitable for emulsion type cooked meat than native chicken meats. For non-emulsion type processed products, Paraokan meat has the highest processing potential due to its high meat yield, high protein content, low fat content, low free water and high bound water (Tables 1, 2, and 4).

CONCLUSION

Meat from various genetic groups of native chicken has the potential as a healthy substitute to broiler because these have higher crude protein and lower fat contents than commercial broiler. Furthermore, the meat yields of the different genetic groups of native chickens were similar to commercial broiler. On the other hand, commercial broiler has better functional properties for emulsion type cooked meat than native chicken meat because of its significantly higher pH, emulsion activity and emulsion stability. Among the native chickens, Paraokan has the highest processing potential for non-emulsion type processed products due to its high protein, low fat, low free water, high bound water and high meat yield.

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