COMPARATIVE STUDY ON CARCASS AND MEAT QUALITY CHARACTERISTICS OF FARM REARED NATIVE, BACKYARD NATIVE AND GIRIRAJA CHICKEN

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KARNATAKA VETERINARY, ANIMAL AND FISHERIES SCIENCES UNIVERSITY, BIDAR

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By

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CERTIFICATE

This is to certify that the thesis entitled "***COMPARATIVE STUDY ON CARCASS AND MEAT QUALITY CHARACTERISTICS OF FARM REARED NATIVE, BACKYARD NATIVE AND GIRIRAJA CHICKEN***" submitted by **Ms. ANUSHABAI,** I.D. No. **MVHK 1835** for the award of degree of **MASTER OF VETERINARY SCIENCE** in **LIVESTOCK PRODUCTS TECHNOLOGY** is a record of research work carried out by her during the period of her study in this University, under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associate ship, fellowship or other similar titles.

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Affectionately dedicated to my

Parents and Teachers

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

%	:	Per centage
a*	:	Redness
BSA	:	Bovine Serum Albumin
BNC	:	Backyard native chicken
C	:	Control
CIE	:	Commission International De l'Eclairage
DP	:	Dressing per centage
et al	:	*et alia*
FNC	:	Farm reared native chicken
GR	:	Giriraja chicken
gm	:	Gram
h	:	Hour
HCl	:	Hydrochloric acid
HCW	:	Hot carcass weight
kg	:	Kilogram
KOH	:	Potassium hydroxide
L*	:	Lightness
M	:	Molar
MFD	:	Muscle fibre diameter
mg	:	Milli gram
ml	:	Milli liter
mM	:	Milli molar
N	:	Newton

PSW	:	Pre slaughter weight
rpm	:	Rotations per minute
SE	:	Standard error
Sec	:	Seconds
SF	:	Shear force
SL	:	Sarcomere length
TCA	:	Trichloro acetic acid
UV - VIS	:	Ultraviolet–visible spectroscopy
v/v	:	Volume by volume
w/v	:	Weight by volume
WBSF	:	Warner Bratzler (WB) Shear Force Value
WHC	:	Water holding capacity
μ	:	Micron
μg	:	Micro gram
μl	:	Micro liter

Introduction

I. INTRODUCTION

Meat and meat products serve as an excellent source of good quality protein with high biological value and essential amino acids, fats, minerals (*e.g.*, zinc, iron and phosphorus), vitamins, and other valuable or essential nutrients and hence has always been an integral part of human nutrition worldwide (Zhang *et al*., 2010). Meat consumption pattern in majority of the countries is culture dependent, and in India, meat consumption pattern is controlled by customs, tradition and religious taboos. Of the various meats consumed in India, poultry meat occupies the major share among various sections because of its versatility, relatively low cost; no social and religious taboo associated with its consumption and is considered to be lean with low fat content. Chicken meat in India is generally obtained from broiler, indigenous chicken and spent hen (Devi *et al*., 2014).

Commercial broiler occupies the majority of the market share (85-90 %) of poultry meat in India and the remaining 10-15 per cent is contributed by sale of native local chicken (Rajkumar *et al*., 2016). As per the Department of Animal Husbandry & Dairying, during 2016-17, India has produced 7.4 million tons of meat, which constituted around 2.7 percent the global meat production and 3.33 million tons (45%) was contributed by poultry (Basic Animal Husbandry Statistics, 2018).

The commercial broiler because of their genetic potential is fast growing with high feed conversion efficiency compared to native local chicken which are slow growing poor feed converters but often preferred for the better meat flavour. Native chicken is produced under low input and high output system which is mainly confined to backyard rearing (Wattanachant *et al*., 2004). The meat from desi chicken is preferred because of its pigmentation, taste, leanness, and suitability for special dishes and often fetches higher prices. It is also believed that nature, less intensive management systems provide desi birds with higher welfare levels, resulting in much better product quality (Mir *et al*., 2017). In India there are around nineteen (19) breeds of native chicken that have been recognized and registered as indigenous breeds of chicken in India (NBAGR, 2019).

In addition to native birds, dual purpose birds are being developed and propagated in different part of India for backyard rearing for better productivity and profits to the farmers. Having realized the importance of backyard rural poultry farming in India, several research organizations have developed different backyard chicken varieties (Pathak and Nath, 2013). Giriraja is one such dual purpose meat type breed of chicken developed by Karnataka Veterinary Animal and Fisheries Sciences University, Bengaluru, India which has capability to attain weight of 1.3-1.5 kg by 8 weeks of age as compared to commercial broilers that attain 2.0-2.4 kg in 5-6 weeks (Vinodakumar and Desai, 2017).

In recent years, there has been an increase in demand for meat from indigenous and local birds as consumers perceive the birds reared under extensive system are low in antibiotic and toxic residues. However, indigenous birds in spite of being disease resistant and their meat having unique flavour and taste are slow growing and have poor feed conversion efficiency as compared to broilers. Hence, to bridge the gap between production efficiency, taste, and price line the poultry producers are attempting to grow these indigenous birds under intensive commercial farming system (Singh and Pathak, 2017). Through commercial farming of indigenous birds' producers even though have attained the desired live weight of 1.5-1.7 kg in 15-18 weeks as compared to backyard native chicken

(1.5-1.7 kg in 25-28 weeks), the quality of meat from such birds in comparison with pure backyard native chicken need to be ascertained.

Meat quality is a complex trait that is influenced by genetic and environmental factors (Rehfeldt *et al*., 2004). Therefore, it is important to provide information on quality of meat from these new varieties of birds to help producers and consumers to make informed decisions. Further, little information is known about the meat characteristics of backyard native birds in comparison with native birds reared under farm conditions and dual-purpose meat breeds developed for backyard system of rearing. Hence the present study was undertaken to compare the carcass and meat quality characteristics of backyard native chicken, farm reared native chicken and Giriraja chicken in Karnataka with the following objectives:

1. To assess the carcass characteristics of Farm reared native, Backyard native and Giriraja chicken
2. To evaluate the meat quality characteristics of Farm reared native, Backyard native and Giriraja chicken
3. To compare the carcass and meat quality characteristics among Farm reared native, Backyard native and Giriraja chicken

Review of Literature

II. REVIEW OF LITERATURE

2.1 Chicken meat

Chicken meat is the cheapest source of animal protein and is the second most preferred meat after pork in the world and most preferred meat in India. Commercial broilers contribute up to 85–90 per cent of chicken meat in India and the contribution of native chicken is very less only 10–15 per cent (Rajkumar *et al*., 2016).

In India, the major contributor of meat among poultry is the commercial broilers with a total production of 3.8 million tons and further growing at a rate of 10–12 per cent. However, a section of Indian meat consumers has acquired a preference for the taste of meat from native breeds over that of broiler meat. The total value of output from native backyard system of poultry rearing is 15% and the market for native breeds for meat is steadily growing (Chatterjee and Rajkumar, 2015).

Jayasena *et al*. (2013) opined that scientific evidences need to be established to demonstrate the unique flavor of native local chicken as compared to those of broilers and it is much important to elucidate the physicochemical factors that influence the taste and nutritional value of these chickens.

Broiler meat has been reported to be healthier than red meat because it has low cholesterol and fat content. In addition, broiler meat is juicier and is a good source of protein, minerals and vitamins that are key to human growth. Unlike pork and beef, no religious beliefs forbid their consumption. Many factors such as genotype (strain), diets content, sex, design of pen and stocking density have been reported to affect the performance, meat quality and carcass yields of broiler chickens (Olawumi and Fagbuaro, 2011).

The native chickens are slow growing, poor feed converters and often preferred because of its intense flavour, firm texture, low fat and rich nutrients (Zhao *et al*., 2007; Chen *et al*., 2008).

The increasing demand for chicken meat has made farm households to produce more broilers, especially on large scale, because they can be sent to the market within 5 to 6 weeks, providing more economical benefits (Choe *et al*., 2009; Jayasena *et al*., 2013). Their meat has a high nutritive value, good taste and aroma and soft texture and is relatively cheaper in price (Suriani *et al*., 2014).

2.2 Carcass characteristics

Kondaiah and Panda (1987) reported a yield of 66.50 per cent (565 g per bird) deboned meat from spent layer hens (White leghorn). They reported that meat and fat yield varied with the age and weight of bird, with heavy hens produced better yields and better-quality products than lighter weight birds.

Bandey and Risam (2001) studied carcass characteristics in the commercial broiler and reported that average body weight gain as 846 ± 10.80 and 1245 ± 21.62 at 28 and 42 days, respectively. They further recorded shrinking per cent, dressing yield, eviscerated per cent, giblet yield and edible meat yield as 2.98 ± 0.55, 84.62 ± 0.68, 66.95 ± 0.81, 3.28 ± 0.10,70.23 ± 0.65 percent respectively.

Singh *et al*. (2001) reported a dressing per centage of 66.83 per cent in commercial broiler and per centage of different parts as 3.60 (blood), 3.39 (head) 5.54 (shank), 5.43 (feather) and 15.17 (offal and organs).

Das *et al*. (2005) stated that the per cent dressed weight, eviscerated weight, giblet weight of vencobb chicken at 5-6 weeks were 89.18 ± 0.01 ,69.23 ± 0.15 and 6.13 ± 0.05, respectively.

Rahayu *et al*. (2008) reported that in chicken irrespective of genotype, the weight of heart, gizzard, spleen and lungs were similar between male and female, but not the liver which was heavier in females than males.

Rajan *et al*. (2014) sated that the average live weight of spent hen was 1.12 kg and average boneless meat yield per bird was 0.24 kg. The yield of boneless meat from thigh and breast region of spent hen was 21.06 percent of its live weight.

Rao and Ranganadham (2011) observed that the body weights (kg) of broilers of six and seven-week-old at the time of slaughter were 1.74 ± 0.45 and 2.56 ± 0.23. The mean per cent blood loss, feather along with skin and evisceration losses were 5.21 ± 0.23, 25.28 ± 0.33, 36.78 ± 0.22 and 2.84 ± 0.34, 22.73 ± 0.12, 34.52 ± 0.23, respectively. The per cent carcass yield was significantly higher in seven-week-old birds when compared to six-week-old birds and no significant difference was evident in the yield of giblets and various cut up parts of both the age groups.

Poltowicz and Doktor (2012) studied the carcass characteristics of hybrid birds resulting from the crossing of 4 lines of native chickens with Hubbard male broilers and concluded that in hybrids aged 12 weeks, the body weight varied from 2126 to 2968 g and dressing percentage was in the 70.66–76.26 per cent.

Haunshi *et al*. (2013) reported that the dressing per centage of 20 weeks age Aseel and Kadaknath birds was 66.47 ± 0.68 and 64.80 ± 0.72, respectively.

Sobana *et al*. (2013) reported that the average live weight of spent hen and broiler birds was 1.5 kg and 2.6 kg respectively and the average dressing per centage (without skin) in spent hen and broiler was 45.48 and 60.51, respectively.

Nielsen *et al*. (2003) reported that slow-growing chickens were characterized by a lower breast yield, but higher yield of thigh and drumstick meat than fast-growing chickens.

Patel *et al*. (2014) stated that the mean body weight of birds at 20 weeks of age under backyard system of management was significantly lower in comparison to deep litter and semi-intensive system of management. The dressing percentage with giblet of Gramapriya birds under deep litter, semi-intensive and backyard system of management were 76.16 ± 1.02, 75.00 ± 0.66 and 73.88 ± 0.49 respectively, in case of male birds and 67.20 ± 1.44, 63.97 ± 0.64 and 66.04 ± 0.78, respectively, in case of female birds. Different management system had no significant effect on any of the organoleptic parameters like colour, odour, texture, tenderness, juiciness, taste and over all acceptability.

Rajkumar *et al*. (2016) recorded a dressing percentage and meat: bone ratio of 69.54 ± 0.15 and 1.07:1.0 in Aseel and 69.08 ± 0.15 and 1.31:10 in broiler chicken. Meat proportion and meat bone ratio (M: B ratio) was significantly (P<0.001) higher in commercial broilers compared to Aseel, whereas bone proportion was significantly higher in Aseel. The live weight and primal cuts (legs and breast) had significant ($p<0.001$) interaction effects between broiler and Aseel and the giblet (heart, liver, gizzard) weight did not vary significantly between Aseel and broilers. The offal proportions, like skin and feather, varied significantly ($P <0.005$) between the Aseel and broiler.

Marapana (2016) observed that the yield of edible offal in commercially reared (1.8-2.0 kg body weight) broiler birds such as neck, wing, gizzard, liver, heart and total giblet were 3.22 ± 0.50, 9.97 ± 1.04, 1.57 ± 0.25, 2.58 ± 0.32, 0.69 ± 0.08 and 4.85 ± 0.66 percent, respectively.

Muthulakshmi *et al*. (2016) reported that the slaughter weight, dressed carcass weight, dressing percentage and weight of heart, liver, gizzard, shank, intestine, head and skin of culled spent layer hen were 1.17 ± 0.02, 0.73 ± 0.01, 62.39 ± 0.02 and 5.73 ± 0.19, 23.49 ± 0.93, 38.58 ± 0.54, 97.82 ± 5.02 ,56.56 ± 1.41 and 96.16 ± 8.75, respectively.

Singh and Pathak (2017) observed that the dressing percentage of broiler strain (Cobb-400) was significantly higher than all indigenous breeds (Aseel, Kadaknath, Vanaraja) and hot carcass weight of Aseel was significantly higher than Vanaraja and Kadaknath. The meat bone ratio of broiler strain (Cobb-400) was significantly higher than the ratio obtained in all indigenous chicken breeds, among the indigenous breeds (Aseel, Kadaknath, Vanaraja) meat bone ratio did not show any significant difference with each other.

Devatkal *et al*. (2018) reported that the slaughter weight (kg), dressed weight (kg), dressing percentage, meat bone ratio and yield of giblet (%) was 1.75, 1.27, 72.56, 5.41 and 6.68 in white commercial broiler and in Aseel birds were 0.85, 0.69, 71.11, 4.00 and 6.88, repectively.

Ikusika *et al*. (2020) examined strain, sex and slaughter weight effect on performance, meat quality and yield of broiler chicken and observed that Aboaca birds had higher carcass yield and lower visceral weights compared with Ross and Anak chicken. They also reported that the female broilers chicken had higher weight ($P < 0.05$) for back and thigh and lower weight for breast meat, drumstick and wing weight than the male broiler.

Rajkumar *et al*. (2020) observed that Aseel crosses with colored broiler lines (PB-1 and PB-2) had significantly ($P \leq 0.05$) higher body weights as compared to PD-1, PD-2 and PD-6 crosses at all ages, which they attributed to the fast-growing broiler inheritance present in colored broiler lines.

2.3 Physico-chemical parameters

2.3.1 pH and Water holding capacity

Demarchi *et al*. (2005) reported that in Padovana breed of chicken the pH of the breast and thigh muscle was significantly affected by sex of the bird. Percentage of breast and thigh pH was greater for females than males and the pH of breast and thigh muscles of male and female were 5.83 and 5.79 and 6.03 and 6.14, respectively.

Fanatico *et al.* (2007) found that a free-range production system resulted in significantly lower water holding capacity. This lower WBC indicated losses in the nutritional value through exudates that were released and this resulted in drier and tougher meat. Similar results were reported by Wang *et al*. (2009) in slow growing chicken.

Abdullah and Matarneh (2010) stated that in broilers aged between 32 days and 42 days, no significant difference was observed among ages and strain for water holding capacity of breast meat.

Souza *et al*. (2011) observed that ultimate pH of thigh muscle was higher compared to breast muscle and reported no significant effect of sex on ultimate pH in broilers.

Sampaio *et al*. (2012) reported that breast and thigh meats exhibit pH values of 5.7–6.4 and 6.3–6.9 during storage, respectively. They also opined that pH values of meat can influence various physicochemical characteristics like colour, WHC and tenderness.

Sanka and Mbaga (2014) opined that thigh muscle had higher pH as compared to breast, which might be due to higher muscle activities in leg muscles than breast muscle and male had higher ultimate pH as compared to females implicating the males were probably more active than female birds.

Kumar *et al.* (2012) reported that the pH and water holding capacity (percentage) of fresh chicken meat was 5.75 ± 0.05 and 40.50 ± 0.99, respectively. The meat of young native chicken had significantly ($P<0.05$) lower pH value compared to adult birds (Ilavarasan *et al.*, 2016).

Lakshani *et al.* (2016) observed that the pH and water holding capacity in broilers was 6.45 and 77.32 percent, in spent hen was 6.02 and 74.21 percent and in Aseel birds was 5.92 ± 0.02 and 75.31 per cent.

Reddy *et al.* (2016) reported that the pH values were significantly higher in spent layer hen (6.42 ± 0.01) compared to spent breeder and broiler hen meat (5.87 ± 0.23 and 6.10 ± 0.13). They also reported a significantly ($p<0.05$) higher water holding capacity in spent breeder hen meat (14.41=0.11 per cent) compared to broiler and layer (11.45=0.52 and 9.65=0.27 percent).

Muthulakshmi *et al.* (2016) reported that the pH, shear force value (N/cm), water holding capacity (%), muscle fiber diameter (micro meter) and collagen content (mg/g) of culled layer hen was 6.20 ± 0.06, 18.41 ± 2.39, 35 ± 0.40, 5.5 ± 0.23 and 6.84 ± 0.43, respectively.

The meat of young native chicken had significantly ($p<0.01$) higher water holding capacity than adult suggesting that birds slaughtered at young age have better juiciness compared to adult birds since water holding capacity of meat is closely related to tenderness and juiciness (Ilavarasan *et al*., 2016).

Rajkumar *et al*. (2017) observed pH value of meat from Aseel birds slaughtered at 20 weeks of age was 6.0 ± 0.03.

Reddy *et al.* (2017) described that the values for physical parameters (pH, water holding capacity, muscles fibre diameter and shear force value) of 24 weeks old male Rajasri chicken were 5.78 ± 0.02, 21.15 ± 0.01 percent, 63.93 ± 0.06 micro meter and 12.83

for breast meat and 5.91 ± 0.02, 22.79 ± 0.06, 69.01 ± 0.11 and 18.0 ± 0.05 for thigh meat, respectively. The values in female Rajasri breast meat were 5.79 ± 0.01, 21.17 ± 0.03, 63.86 ± 0.04 and 13.16 ± 0.04 and thigh meat of female Rajasri chicken meat was 5.93 ± 0.02, 22.82 ± 0.02,68.96 ± 0.05 and 22.57 ± 0.04 respectively.

Devatkal *et al*. (2018) reported that the pH (after one hour of slaughter), Water holding capacity (%), muscle fibre diameter (µm) and shear force value (N/cm) was 6.32, 7.50, 64.16 and 7.16 in commercial broiler, and in Aseel were 6.35, 30.95, 60.17 and 11.16, respectively. They observed that pH, water holding capacity and Shear force value was significantly ($p<0.05$) higher in Aseel compared to white commercial broiler. Muscle fibre diameter did not vary significantly among broiler and Aseel.

Kadioglu *et al*. (2019) found that thigh meat with relatively high pH values had higher WHC than that of breast meat with relatively low pH values. Several other researchers have observed greater water absorption ability of myofibrillar proteins in the breast muscle compared to myofibrillar proteins from the thigh muscle

Choe and Kim, (2020) evaluated physico-chemical characteristics of breast and thigh meats from old broiler breeder hen (OBH) and old laying hen (OLH) and observed that the pH values of breast meat were not affected by the chicken breed. However, for thigh meat, OBH had higher pH values than those of OLH. Regardless of chicken breed, thigh samples had significantly higher pH values than breast samples. They also observed that the WHC and cooking loss was 44.7– 52.7 and 27.2–36.3 per cent, respectively and that higher WHC and lower cooking loss was observed in breast meat of OBH compared to OLH. No significant differences in the WHC and cooking loss in thigh meat were observed between OBH and OLH. The WHC and cooking loss were influenced by the chicken muscle location, with a higher WHC and lower cooking loss in breast samples with lower pH values.

2.3.2 Muscle fibre diameter and Sarcomere length

Jeremiah and Martin (1978) have studied the effect of sex and breed on sarcomere length of meat in bovine and reported that sex and breed has significant effect on sarcomere length and significant difference in post rigor *Longissimus dorsi* sarcomere length were observed in carcass with ageing time of 6 and 20 days.

Thompson *et al.* (1987) reported that the sarcomere length of broiler breast fillets was 1.79 micrometer.

Dunn *et al*. (2000) opined that shear force value and sarcomere length showed negative correlation in duck and chicken breast meat and that sarcomere shortening was a major contributor to the toughness of meat and higher sarcomere length resulted in lower shear force values.

Cavitt *et al*. (2004) observed that in broiler chicken as the ageing time increased the sarcomere length also increased and the sarcomere length of broiler chicken ranged from 1.57 µm to 1.71 µm.

Broiler chickens have more muscle fibers of greater size and their breast muscles grow 8 times as fast as in layer hens (Hassanpour *et al*., 2010). The size of muscle fibers and their growth rate is 2- to 3-fold greater in broilers than in layers (Zheng *et al*., 2009).

Zhao *et al*. (2011) compared Chinese local chicken breed (Beijing-you- BJY) and a genetically improved broiler line (Arbor Acres- AA) and observed that the breast muscle fibre diameter was significantly smaller and fibre density was higher in BJY chickens than in AA chickens.

Buzala and Janicki (2016) reported that greater size of muscle fibre was observed in broilers compared to laying hens.

A close relationship between WHC and sarcomere length was reported by Ertbjerg and Puolanne (2017), who found that the WHC was lower when sarcomere was shortened as a result of the stronger pull generated by a larger number of cross-bridges or a decrease in electrostatic repulsion due to the long distance between longitudinal filaments.

Choe and Kim (2020) observed that the sarcomere lengths, defined as the area between 2 Z-lines, for chicken meat samples were significantly influenced by the chicken breed and muscle location, ranging from 1.36 to 1.60 µm. The old breeder hen samples showed longer sarcomere lengths, regardless of muscle location. Significantly longer sarcomere was observed in thigh meat than in breast meat.

2.3.3 Total collagen

The collagen content remains constant within each muscle, with increase age of the animals, but the heat stability of this component increases due to the formation of non-reducible links between chains which results in increased tensile strength (Lawrie, 1991). An age-related increase in pyridinoline content of intramuscular collagen and crosslink formation influenced by sex contributed to the toughness of meat in spent groups

(Bosselmann *et al*., 1995). Tenderness decreased with increase in age of the animal due to higher collagen content and formation of stable collagen cross links (Murthy and Devadason, 2003).

Wattanachant *et al*. (2004) observed that indigenous chicken muscle contained more total collagen but less soluble collagen than those of broiler muscles and they opined that the difference in the collagen content between two breeds could be attributed to difference in the ages of the birds at slaughter.

Intarapichet *et al*. (2008) conducted a study to determine chemical compositions of 4-lines and 5-lines cross of Thai hybrid native chicken meats as compared to those of commercial broiler at the market weight of 1.8 kg. They observed a significant difference in all types of collagens in the breasts between sexes within and among chicken breeds. Male chickens contained higher collagen of which the 4-lines cross breed was the highest in all types of collagens. Both male and female broilers contained the least amounts of collagen of which the 5-lines cross breed was in between the other two breeds. Collagen content of chicken thigh was higher and less soluble.

Lin *et al*. (2014) evaluated the meat quality characteristics of Taiwan game hens reared in cage, floor pen and free-range and observed that the free-range group had the lowest fat content in breast and thigh meat, and the lowest calorie content in thigh meat. The crude protein and total collagen contents in thigh meat and total collagen content in breast meat of the free-range group were significantly higher than those of the cage

Chumngoen and Tan (2015) evaluated the sensory attributes of commercial broiler (BR) and Taiwan native chicken (TNC) breast meat, and investigated the correlations between these sensory attributes and instrumental measurements. They observed that TNC meat had significantly higher total collagen content (6.50 mg/g sample) than BR meat (3.98 mg/g sample).

Reddy *et al.* (2016) reported that greater collagen content was found in spent layer meat (4.89 mg/ gm) and lower collagen content found in breeder hen (3.25 mg /gm) meat. A significantly high moisture and fat content were found in spent broiler meat and lower protein was also found in broiler meat highest protein content was found in spent breeder hen meat compared to other spent birds.

Chen *et al.* (2016) compared the physicochemical and nutritional properties of breast and thigh meat from commercial Chinese crossbred chickens (817C), imported commercial broilers (AAB), and commercial spent hens (HLB). They observed that soluble collagen, total collagen and collagen solubility of thigh meat were higher than that in breast meat regardless of chicken breeds except for the collagen solubility of 817C. Furthermore, it was also found that soluble collagen, total collagen and collagen solubility of 817C, AAB and HLB exhibited significant difference regardless of the meat portions. HLB showed the highest total collagen of breast meat and thigh meat, which were 4.01 and 7.47 mg/g, respectively, whereas the HLB also exhibited the lowest collagen solubility in both meat portions. They opined that the differences in the collagen characteristics among the three breeds could be attributed to differences in the age of the birds at slaughter.

Hydroxyproline (HP) content was 190.51 ± 4.47 for Aseel and 92.12 ± 5.80 for broilers. Hydroxyproline contents were significantly higher in Aseel chickens (Rajkumar *et al*., 2016).

Limpisophon *et al.* (2019) compared the characteristics and properties of breast meat from spent Lohmann Brown layers (SP) and those of commercial broilers (BR) and observed that the SP samples composed of a significantly greater total collagen. Additionally, collagen networks of the SP increased in thermal stability as reflected by the lower soluble collagen content and collagen solubility. However, on cooking, collagen in both SP and BR samples could be solubilized to the greater extent, indicating the breakdown of collagen networks in both samples during cooking. Solubility of the collagen in the SP was lower than that of the BR.

Rajkumar *et al*. (2020) in their study observed that hydroxyproline (HP) concentration was significantly ($P \leq 0.05$) higher in Aseel × PB-1 and Aseel × PD-2 crosses. Higher HP concentration in chicken meat indicated high content of collagen fibres in the meat. They observed that Aseel × PD-6 cross recorded significantly lower HP level as indicated by lower shear force strength revealing that the meat was tender compared to other crosses.

2.3.4 Shear force value (SFV)

Wattanachant *et al*. (2004) reported that the muscle of 16-week Thai native chicken, and observed that native chicken had a thick perimysium and high collagen content, exhibited higher shear force value than the muscle of the 38 day commercial broiler. They explained that the genetic backgrounds of different breeds determine perimysium thickness and collagen content, producing the observed differences in the textural properties of the meat.

Musa *et al*. (2006) reported that the SFV for male and females' chicken were 2.94 to 3.56 kg/cm^2 and 2.32 to 2.94 kg/cm^2 and found that males had higher SFV than females and meat from males were tougher than females and the tenderness decreases as the age increases.

Tang *et al*. (2009) reported that the older slow-growing birds of 110 days age had higher SFV than the fast-growing birds of 49 and 56 days of age, which could be explained by the differences in collagen cross-linking. Further, they observed that increase in the amount of connective tissue with age might have contributed to the higher SFV in slow-growing indigenous birds and other genotype birds studied in their experiment.

Abdullah *et al*. (2010) observed significantly interaction in SFV between age and aging time in broiler chicken breast meat and they observed that as the age of slaughter increase the SFV increased.

Devatkal *et al*. (2018) observed that the SFV of breast meat was significantly ($P < 0.05$) higher in Indbro Aseel (ASR) and Aseel (ASL), followed by Rainbow rooster (RR) and Rainbow rooster plus (RRP), and lowest SFV were observed in Aseel (WBR). They opined that, birds carrying Aseel germ plasm had a higher SFV than broiler birds. Similarly, rainbow rooster birds (both RR and RRP) had significantly ($P < 0.05$) higher SFV than WBR.

Higher SFV have been reported in Thai indigenous chicken (Jaturasitha *et al*. 2008), in native Chinese chickens (Chen *et al*. 2008) and in Indian Aseel chicken (Rajkumar *et al*. 2016).

2.3.5 Colour score

The colour of fresh meat is an important attributed for the consumer and the temperature at which muscles enter into rigor during the conversion of muscles to meat affects meat colour (Hood, 1980).

According to the Livingston and Brown (1981) myoglobin is the main pigment responsible for meat colour and the form that this protein takes in these muscle foods is of prime importance to the main quality indices of importance to the consumer. These factors are responsible for meat colour physical structure of the meat pigment concentration and the chemical state of the pigments.

Jung *et al*. (2011) compared meat characteristics of Korean native chicken Woorimatdag (WM) and a commercial broiler (Ross, CB) and observed that the crude fat contents of WM thigh meat were lower than those of CB and WM thigh had higher L* and a*values and lower b* values. WM thigh meat showed higher collagen content, hardness, springiness, gumminess, and chewiness than CB.

Devatkal *et al*. (2018) observed that in fresh and chilled thigh, L* value did not vary significantly among various genotypes of birds. Fresh and chilled thigh from Aseel showed highest significant ($P < 0.05$) redness (a*) values compared to other genotypes. Highest yellowness (b*) for fresh thigh and chilled thigh was reported in Aseel and broilers, respectively. Fresh and chilled thigh from broiler revealed highest hue values, whereas fresh thigh from Aseel and chilled thigh from both Aseel and broilers showed highest chroma values.

Khan *et al*. (2019) in their comparative study on carcass traits, meat quality and taste in broiler, broiler breeder and Aseel chicken observed that that female Aseel chickens exhibited a higher yellowness (b*) value than males.

Rajkumar *et al*. (2020) in their study on carcass characteristics of five Aseel crosses (Aseel x PD-1, Aseel x PD-2, Aseel x PD-6, Aseel x PB-1 and Aseel x PB-2) observed that the lightness, (L*) did not show any significant variation while, yellowness (b*) and redness (a*) differed significantly among the crosses indicating the presence of variable myoglobin content in the muscles. They observed that the crosses with rural pure lines had significantly ($P \leq 0.05$) higher redness and yellowness values as compared to the broiler crosses which had significantly low coloration.

2.3.6 Proximate composition

Wattanachant *et al.* (2004) stated that indigenous chicken muscles contained higher protein but lower fat and ash content than those of broiler muscles.

Demarchi *et al.* (2005) reported that in Padovana breeds of chicken there was significant difference in chemical composition of the breast muscle except for the percentage of dry matter and ash content between male and female and no difference between ages for chemical composition expect for protein. The dry matter, protein, lipids and ash content of male and female were 25.37 and 25.46 per cent, 22.8 and 22.67 per cent, 1.39 and 1.59 per cent, 1.19 and 1.24 per cent, respectively.

Jaturasitha *et al*. (2008) reported that moisture and protein contents of the breast muscle did not significantly differ among genotype in chicken. The moisture, fat and protein content of native chicken were 72.1, 24.4 and 0.51 per cent and that of Rhode Island Red chicken were 73.7, 23.6 and 0.76 percent, respectively. Similarly, Liu and Niu (2008) also reported higher fat % in a broiler-type bird (Arbor Acres) compared to native quality chicken (White Lueyang).

Chueachuaychoo *et al*. (2011) reported that meat from spent hen is good protein source, highly enriched with omega-3 fatty acids and lower in cholesterol content in particular breast muscle, which have been shown to have health promoting benefits. They further revealed the moisture, protein, fat, ash and cholesterol content of *Pectoralis* muscles of spent hen chicken were 74.16, 22.34, 3.11, 1.19 per cent and 34.6 mg/100 mg.

No significant difference was observed in crude protein and fat percentage of breast and thigh muscles among native chicken breeds (Aseel and Kadaknath), however, dry matter percentage of both breast and thigh muscles were significantly higher in Aseel. They opined that this difference may due to the fact that kadaknath birds tend to accumulate higher abdominal fat and hence more water retention in thigh and breast muscles (Haunshi *et al*., 2013).

Valavan *et al*. (2016) reported highest quantity ($P < 0.01$) of protein and crude fibre in broiler meat as compared to native chicken. The crude fat content of native chicken was significantly lower than the commercial broiler and a significantly ($P< 0.01$) higher amount of ash content was noticed in native chicken than from broiler meat sample.

Marapana (2016) reported that the moisture, protein, fat and ash content of breast of 1.8 to 2.0 kg body weight broiler bird was 73.58 ± 0.40, 21.10 ± 0.48, 6.36 ± 1.42, 2.19 ± 0.05 per cent and that of thigh meat was 74.90 ± 0.55, 17.66 ± 1.28, 22.85 ± 0.80 per and 2.09 ± 0.07 per cent. Crude protein and ash content was significantly ($P<0.05$) higher in breast meat and crude fat content was significantly ($P<0.05$) higher in thigh meat.

Rajkumar *et al*. (2017) reported that the protein, fat, ash and moisture content of 20 weeks age Aseel meat was 21.5 ± 0.5, 3.4 ± 0.01, 2.0 ± 0.01 and 73.3 ± 0.5 per cent, respectively.

Devatkal *et al*. (2018) observed that Indbro Aseel (ASR) and broiler had a significantly ($P < 0.05$) lower moisture and higher dry matter percentage as compared to rainbow rooster, rainbow rooster plus and Aseel birds. Moisture content was highest in Aseel birds followed by rainbow rooster. Protein content was significantly higher ($P < 0.05$) in ASR followed by broiler and rainbow rooster birds and lowest in Aseel. Broilers and rainbow rooster plus had the highest amount of fat (>8%) and Aseel birds had the lowest amount of fat (3.18%).

Rajkumar *et al*. (2020) observed that the protein and moisture content did not differ significantly, while fat and ash proportion varied significantly ($P \leq 0.05$) among the various Aseel crosses. They observed that the protein and fat content across various Aseel crossed ranged from 23.56 to 23.78 per cent and 3.25 to 3.69 per cent, respectively.

2.3.7 Cholesterol content

Suriani *et al*. (2014) reported that the highest cholesterol content was found in broiler meat and the lowest was in indigenous chicken. They opined that the slow growth rate and feeding system of indigenous chicken could be the reason for this difference.

Total lipid content in broiler meat ranged between 1 and 7 g/100 g and the Cholesterol content in broiler chicken muscle ranged from 30– 180 mg/100 g (Anitha *et al*. 2007).

Salma *et al*. (2007) reported higher (93.6 ± 9.4 mg/100 g) cholesterol content in the breast meat of broilers. Higher cholesterol contents of 147.0 mg/100 g (Demirel *et al*., 2012) and 194.2 mg/100 g (Salma *et al*., 2007) were reported in thigh muscles in broiler chickens.

Cholesterol content of Aseel breast meat was low (72.5 ± 6.7 mg/100 g) as compared to broilers and it might be due to more metabolic activity under free-range conditions and lean meat of the bird, which is a desirable feature for meat purpose birds (Rajkumar *et al.*, 2017).

Ali *et al*. (2019) compared the composition and nutrient content of commercial native chicken (HH) and three newly bred native chicken strains (2A, 2C, and 2D) and observed that Cholesterol contents of HH, broiler, 2A, 2C, and 2D were 51.26 (mg/100 g), 63.17 (mg/100 g), 54.43 (mg/100 g), 49.04 (mg/100 g), and 49.51 (mg/100 g) respectively. But among new native chicken strains, 2C and 2D implied the lower inflate of cholesterol than HH.

2.3.8 Sensory Characteristics

To determine the acceptance of meat or food products, consumers consider several characteristics, such as its sensory characteristics, its nutritional value and its impact on health. In chickens, as well as other types of meat, meat colour, method of processing, exposure to chemicals, method of storage, and method of cooking influence sensory characteristics (Muchenje *et al*., 2008).

Jeon *et al*. (2010) observed no significant difference in sensory evaluation among the three different strains viz., North Korean native chickens (NKNC), South Korean native chickens (SKNC, Woorimotdak) and commercial broilers (CB) except for the meat colour.

Dyubele *et al*. (2010) conducted a study to determine the effect of breed on carcass characteristics and consumer sensory characteristics of broilers and indigenous chicken meat and observed that overall, breed had significant effects on most sensory characteristics, where broiler chicken meat received higher consumer sensory scores than meat from indigenous chickens ($P < 0.05$). Overall flavor, aroma intensity, and off-flavor intensity scores were similar between the broiler and indigenous chicken meat ($P > 0.05$).

Lin *et al*. (2014) evaluated the meat quality characteristics of Taiwan game hens reared in cage, floor pen and free-range and observed that meat sensory scores of flavor, chewiness and overall acceptability of both thigh and breast meat of the free-range group were significantly better than those of the other groups in both breast and thigh meat.

Premavalli *et al*. (2018) compared sensory characteristics of breast meat of different chickens viz., commercial broiler (35 days), Aseel (90 days) and colour broiler (56 days).

They observed commercial broiler chicken and Aseel had significantly higher ($P \leq 0.01$) flavor score, tenderness, overall acceptability and significantly higher ($P \leq 0.05$) appearance score than colour broiler meat. The breast meat colour was dark red in Aseel, pale pink in commercial broiler and yellowish in colour broiler. However, juiciness was significantly higher ($P \leq 0.05$) for commercial broiler than Aseel and colour broiler.

Khan *et al*. (2019) compared the sensory attributes of thigh and breast meat from broilers, broiler breeder and Aseel. They observed that Aseel breast meat received lower scores for flavor, juiciness and tenderness, than those of broilers and broiler breeders. The panel found no color, aroma, taste or acceptability differences in the breast meat of the three genotypes. No significant differences between the sexes ($p > 0.05$) were found for any breast meat sensory characteristics. Flavor and juiciness values of broiler female breast were higher as compared to Aseel male, whereas breast of Aseel female and Broiler breeder of both sexes showed intermediate values. Regarding thigh meat, Aseel scored lower for color and acceptability than those of broiler breeders and broilers. The panel found no difference in aroma, taste, flavor, juiciness and tenderness among three genotypes.

Materials and Methods

III. MATERIALS AND METHODS

The present study was conducted to evaluate the carcass and meat quality characteristics of backyard native chicken (BNC), farm reared native chicken (FNC) and Giriraja birds (GR). The carcass characteristics (dressing percentage, yield of edible and inedible offals, yield of cut up parts and meat and bone ratio) and meat quality characteristic *viz.*, physico-chemical (pH, WHC, colour, drip loss and cooking loss), compositional (proximate composition, cholesterol content and collagen content), structural characteristics (muscle fibre diameter, sarcomere length, shear force) and sensory characteristics were evaluated in both breast and thigh muscle in all three breeds.

3.1 Location of the study

The present study was carried at the Department of Livestock Products Technology, in collaboration with Department of Poultry Science and AICRP on Poultry for Meat, Veterinary College, Hebbal, Bengaluru. Veterinary College is located in Bangalore which is in the southern part of India positioned between 13° 01' N and 77° 35' E at a height of 920 m above sea level. The region experiences usually tropical savannah climate with maximum temperatures ranging from 15 °C in winter to 38 °C in summer.

3.2 Experimental birds

In the present study three groups of birds were used viz., backyard native chicken, farm reared native chicken and Giriraja chicken. Backyard native chicken were procured from native breeding population of Tumakuru district of Karnataka, native chicken hatched and reared in Poultry units of AICRP on Poultry for meat and Giriraja birds reared by the

Department of Poultry Science were used in this study. Farm reared native chicken and Giriraja birds were maintained on ad libitum feeding with maize soya-based diets during the experimental period. The birds were vaccinated against Marek's disease (1^{st} day), Newcastle disease, Lasota (7^{th} and 30^{th} day), infectious bursal disease (14^{th} and 26^{th} day), fowl pox (6^{th} week), ND R2B (9^{th} week) and IB and ND inactivated (18^{th} week). For comparative evaluation of carcass and meat quality characteristics in BNC, FNC and GR birds were selected on the basis of physiological age (approximately equal weight), as the market age is different for these birds. The market age in Giriraja is 8 weeks and 15-18 weeks in case of FNC and 24-28 weeks in backyard native chicken. A total of 120 birds (30 BNC, 30 FNC and 30 GR) were slaughtered in the Experimental Poultry Slaughter facility of the department as per standard procedures and evaluated for carcass traits, meat quality and sensory evaluation.

3.3 Carcass characteristics

3.3.1 Carcass traits

Pre slaughter weight or live weight of the bird were recorded using weighing machine and recorded in grams. Immediately after slaughter, blood was collected in a trough and weighed in a weighing machine. The edible offals (liver, heart, gizzard) and inedible offals (head, feet, spleen, lungs with trachea) were separately weighed. The weight of total internal fats (fats from the kidney, scrotal, pelvic, and heart) was recorded using sensitive balance. The carcass weight after evisceration was also recorded.

3.3.2 Dressing percentage (DP)

The dressing percentage was calculated on the basis of hot carcass weight (HCW) and pre-slaughter weight (PSW) using the formula:

Dressing per cent = Hot carcass weight/Pre slaughter weight x 100

3.4 Meat quality characteristics

3.4.1 Physico-chemical characteristics

The following parameters on the physico-chemical characteristics *viz.*, pH, water holding capacity, drip loss, cooking loss, muscle fibre diameter, sarcomere length and instrumental colour of thigh and breast meat were evaluated.

3.4.1.1 pH

The pH of breast and thigh muscles were estimated after 45min and 24hrs of slaughter using a digital pH meter (Labman, LMPH-10, India) as described by Naveena *et al*. (2004). Ten grams of muscle sample was taken in a beaker and 100ml of distilled water was added. It was homogenized for 15-45 seconds and then the electrode of the pH meter was inserted into the homogenate. The pH was recorded and the probe was thoroughly rinsed with distilled water before each reading. The pH meter was calibrated using pH buffer solutions of pH 4.0 and 7.0 (Thermo Fisher Scientific, Inc, Singapore) at weekly intervals.

3.4.1.2 Water holding capacity (WHC)

Water holding capacity (WHC) was determined according to the protocol of Wardlaw *et al*. (1973). Twenty (20) grams of minced meat sample was placed in a centrifuge tube containing 30 ml NaCl (0.6M) and was stirred with glass rod for 1 minute. The tube was then kept at refrigeration temperature (4 ± 1 °C) for 15 minutes, stirred again and centrifuged at 5000 rpm using refrigerated centrifuge (Eppendorf Centrifuge 5430 R, Germany) for 15 minutes. The supernatant was measured and amount of water retained by samples were measured and WHC was expressed in percentage.

3.4.1.3 Drip loss

Immediately after death, one complete thigh and one complete thigh muscle was weighed and placed in a polyethylene bag. The samples were kept at +4 °C during 24 h, then wiped and weighed. Drip loss was calculated and expressed as the percentage of the initial weight (Remignon *et al*., 1996).

3.4.1.4 Cooking loss

The per cent cooking loss was determined by weight loss after cooking of meat for 1 h in water bath at 80ºC (Babiker *et al*., 1990). The weights of samples were recorded before (raw weight) and after cooking. Cooked weight was divided by raw weight and the result was multiplied by 100 to get per cent cooking yield.

$$\text{Cooking loss (\%)} = (\text{Weight of cooked meat}/\text{Weight of raw meat}) \times 100.$$

3.4.1.5 Colour Analysis

Colour of the sample was tested using Hunter lab Mini scan XE plus Spectrocolorimeter (HunterLab, Model No: MSEZ-4500L, Reston, Virginia, USA) with geometry of diffuse/80 (sphere - 8mm view) and an illuminant of D65/10 deg (Bindu *et al.*, 2007). Colorimetry measures color with quantitative physical methods and can define them within well-established numerical values. Here they are expressed using the standard Hunter L* a* b* system. L*, a*, b* values (non- dimensional units) refer to the three axes of the system: a lightness axis (white-black, L*); and two axes representing both hue and chroma, one red green (a*) and the other blue-yellow (b*). This system provides an unambiguous description of colour and has the advantage that colour differences between samples can be determined using simple computer programs.

The instrument was calibrated with black and white tile (L* = 94, a* = 1.10 and b* = 0.6) every time before the colour measurement was taken. The colour was expressed as L* (brightness), a* (redness) and b* (yellowness). The hue (relative position of colour between redness and yellowness) and chroma (colour intensity) was calculated as follows.

$$\text{Hue} = \tan^{-1}(b^*/a^*)$$

$$\text{Chroma} = \sqrt{(a^*)^2 + (b^*)^2}$$

Average value for each colour parameter was determined by taking observation from six different areas of the same sample.

3.4.2 Compositional characteristics

3.4.2.1 Proximate composition

Proximate compositions such as crude protein, ether extract and ash were estimated as per the procedure outlined by AOAC (2005).

3.4.2.1.1 Moisture

Moisture content was determined by method of (AOAC, 2005). Empty dish and lid were dried in the oven at 105º C for 3 hours and transferred to desiccator to cool. Empty dish and lid were weighed. 3 g of meat sample was weighed to the dish and uniformly spread. Dish was placed in the oven and dried for 3 h at 105º C. After drying, dish was transferred with partially covered lid to the desiccator to cool. Dish and its dried sample were reweighed.

$$\text{Moisture (\%)} = (W1 - W2) / W1 \times 100$$

Where:

W1 = weight (g) of sample before drying

W2 = weight (g) sample after drying

3.4.2.1.2 Crude protein

Total nitrogen was measured by Kjeldahl method. A known quantity of sample (about 0.5-1 g) was taken in Kjeldahl flask and digested with 20-30 ml concentrated H_2SO_4 and 2-3 g of digestion mixture till the solution became colourless. After digestion, the contents were cooled and volume was made to 100 ml. 10 ml of aliquot was distilled in Kjeldahl distillation apparatus (KELPLUS Nitrogen Analyzer) after adding 10-15 ml of

40% NaOH solution. About 60-75 ml of distillate (light green colour) was collected into an erlenmeyer flask containing 10 ml of 2% boric acid indicator solution. The distillate was then titrated against N/100 H_2SO_4 solution and the end point was recorded when colour changed to slight pinkish. Volume of N/100 H_2SO_4 solution used in titration was measured and recorded.

$$\text{N (\%)} = \frac{0.014 \times 0.01 \times \text{Volume of N/100 } H_2SO_4 \text{ used} \times \text{Volume made (ml)}}{\text{Aliquot taken (ml)} \times \text{Sample taken (g)}} \times 100$$

The crude protein (%) of sample was calculated by multiplying the N content with factor 6.25. This was based on the principle that protein contains 16% nitrogen.

3.4.2.1.3 Ether extract

A known quantity of ground sample (about 3 g) was taken in a cellulose thimble and extracted for 8 hours with petroleum ether (40-60°C) in Soxhlet's extraction apparatus attached to a pre weighed oil flask. The oil flask was removed and after evaporating the excess of ether, it was dried overnight in a hot air oven (temp. 100±5°C). The flask was cooled in a desiccator and weighed to a constant value. The ether extract was estimated as the difference in the weight of oil flask with and without oil.

$$\text{Ether extract (\%)} = \frac{\text{(Wt. of oil flask with ether extract – Wt. of oil flask)}}{\text{Wt. of sample}} \times 100$$

3.4.2.1.4 Total ash

A known quantity of sample (about 2.5-5 g) was taken in pre-weighed silica crucible. After charring the sample on heater (till the smoke disappeared), the crucible was kept in muffle furnace for ignition at 550°C for 2-3 h. The crucible was removed on cooling and kept in a desiccator and weighed again to find out weight of ash. The ash content was calculated as given below:

$$\text{Total ash (\%)} = \frac{\text{(Wt. of crucible + ash after cooling – Wt. of oil flask)}}{\text{Wt. of fresh sample}} \times 100$$

3.4.2.2 Cholesterol estimation

Cholesterol content of the meat sample was determined using cholesterol test kit (Recombigen Pvt ltd., India) except that instead of blood serum, lipid extract was used as per the method described by Wybenga *et al*. (1970). Lipid extract was prepared by taking one gram of the sample and adding 10 ml of freshly prepared 2:1 chloroform: methanol solution and homogenised with laboratory model blender.

Homogenate was filtered using Whatman no.42 filter paper. To the filtrate equal quantity of distilled water was added, mixed and centrifuged at 3000 rpm for 7 minutes. Top layer (methanol) was removed by suction. Volume of the bottom (chloroform) layer having cholesterol was recorded. From this 150µl of the sample was pipetted out into a test tube and kept in a water bath (100°C) for 2-3 minutes till it got dried. To this 2.5ml of cholesterol reagent was added, mixed and kept in a boiling water bath for 90 seconds for colour development. The O.D. of standard and test against blank was taken at 530nm.

Total cholesterol (mg/100 g) = [O.D. of sample X Volume of chloroform layer (ml) /O.D. of standard X 0.15 ml] X 25

Where, 25 is the concentration of standard.

3.4.3 Structural characteristics

3.4.3.1 Collagen content

Hydroxyproline content of the meat sample was estimated based on the procedure of Nueman and Logan (1950) with few modifications as recommended by Naveena *et al*. (2004). Meat sample (2 grams) was hydrolysed with 40 ml of 6N HCl for 18 hours. The acid hydrolysate was filtered and the volume was adjusted to 50 ml with distilled water. Then 25 ml of hydrolysate was taken and pH was adjusted to 7.0 using 40% NaOH and the volume was again made to 50 ml with distilled water. 1ml of an aliquot from this solution was used for hydroxyl proline estimation. 1ml of aliquot from pH adjusted acid hydrolysate solution was taken in a test tube, added with an equal volume of i.e., 1ml of copper sulphate, 2.5M NaOH and 6% Hydrogen peroxide and incubated at room temperature for 5 minutes then in water bath at 80^0C for 5 minutes with occasional shaking followed by chilling in ice-cold water. The chilled solution was mixed with 4ml of 3N Sulphuric acid and 2ml of 5% Dimethyl Amino Benzaldehyde (DMEB) in n-Propanol and placed in a water bath at 70^0C for 16 minutes. The absorbance was measured at 540 nm using UV-VIS spectrophotometer (Model: Shimadzu UV-1900, Japan) and also the hydroxyproline content was determined by referring to a standard graph (Figure 3.1). The collagen content was calculated by multiplying hydroxyproline content with 7.14 (Dransfield *et al*., 1983) and was expressed in mg/g tissue.

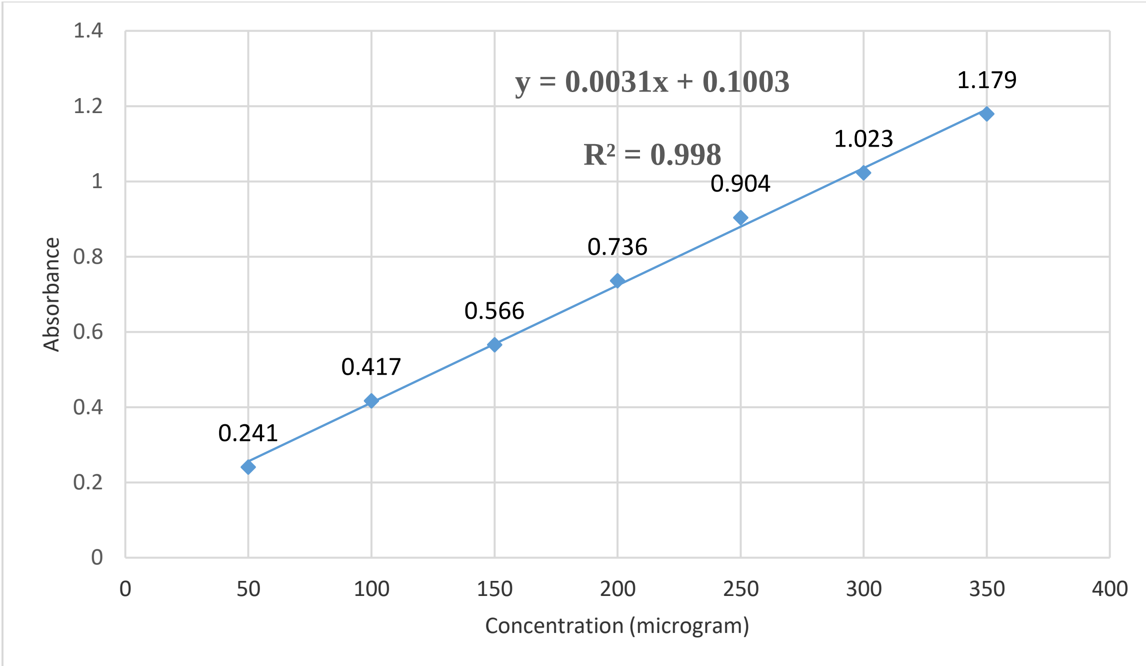

Figure 3.1: Hydroxyproline standard curve

3.4.3.2 Warner-Bratzler shear force

Warner-Bratzler shear force (WBSF) of each muscle sample was determined by the method outlined by Wheeler *et al*. (1997). Each muscle was cooked to an internal temperature of 80ºC (monitored using a probe thermometer), chilled overnight at 2-3ºC before coring. On the next day, three cores of 1.27 cm diameter were taken from each cooked meat along the longitudinal orientation of muscle fibers. These cores were kept at chiller temperature at 2-3°C until they were sheared. Each core was sheared perpendicular to the muscle fibre on a Texture Analyzer (Model: EZ-SX, Shimadzu Corporation, Kyoto, Japan and Shimadzu Autograph Software- Trapezium X) at a cross head speed of 200 millimetres/min. WBSF was expressed in Newton (N) and it was then converted to kg/cm^2.

3.4.3.3 Muscle fibre diameter

Fibre diameter was measured as per the method outlined by Jeremiah and Martin (1977). Five grams of meat sample was cut into small pieces and homogenized into slurry, in a solution containing 0.25M sucrose and 1mM EDTA with a domestic mixer grinder twice for 15 seconds at low speed, interspaced with an interval of five seconds. One or two drops of the slurry were transferred into a microscopic slide and covered with a cover slip. The meat slurry was examined directly under Olympus BX53 phase contrast microscope with image analyzer software under 40X. Muscle fiber diameter was measured as the mean cross-sectional distance between exterior surfaces of Sarcolemma of 20 randomly selected muscle fibers and expressed in micrometer (μm).

3.4.3.4 Sarcomere length

Sarcomere length of each muscle sample was measured as per the method outlined by Hostetler *et al*. (1972). Five grams of meat sample were blended with 35ml of 0.25M sucrose solution for one minute in a domestic mixer grinder at low speed. Immediately after blending, a few drops of slurry containing the fibre fragments were transferred to a microscopic slide and covered with a cover slip. Sarcomere lengths of 25 randomly selected fibre fragments were measured under Olympus BX53 phase contrast microscope with image analyser software under 100X and is expressed in micro meter (μm).

3.5 Sensory Evaluation

The meat samples were cooked at 100 ˚C in a water bath for 30 minutes. The cooked meat chunks were served to semi-trained panellists and evaluated for appearance, flavor, juiciness, tenderness and overall acceptability using an 8-point descriptive scale in a score sheet (APPENDIX) (Where, 8= extremely desirable, 1= extremely undesirable) (Keeton, 1983).

3.6 Statistical analysis

The descriptive statistics for the different types of data were determined as per Snedecor and Cochran (1989). One way ANOVA was performed for data on carcass characteristics and meat quality parameters in thigh and breast muscles of BNC, FNC and GR respectively using GraphPad Prism version 5.00.

Results

IV. RESULTS

The results of the carcass traits and meat quality characteristics of backyard native chicken (BNC), farm reared native chicken (FNC) and Giriraja birds (GR) are presented in this section. The results of meat quality characteristics of breast and thigh muscles from these birds are tabulated and compared separately. In the final section, comparison of thigh and breast meat of individual group of birds was carried out.

4.1 Carcass characteristics

The Mean ± SE of live weight, carcass weight, dressing per centage, yield of breast, neck, back, wing, thigh and drumstick of Backyard Native Chicken (BNC), Farm reared Native Chicken and Giriraja are presented in the Table 4.1.

4.1.1 Live weight (grams)

The Mean ± SE of live weight of BNC, FNC and GR were 1295 ± 45.00, 1390 ± 35.00 and 1714 ± 28.17, respectively. Statistically, there was a significant difference ($P<0.05$) in live weights among all the three groups and higher live weight was recorded in GR followed by FNC and BNC.

4.1.2 Carcass weight (grams)

The Mean ± SE of carcass weight of BNC, FNC and GR were 847.8 ± 24.88, 940.8 ± 24.89 and 1248 ± 21.31, respectively. A significant difference ($P<0.05$) in carcass weights among all the three groups was evident where GR had higher carcass weight followed by FNC and BNC had the lowest carcass weight.

4.1.3 Dressing per centage (%)

The Mean ± SE of dressing per centage of BNC, FNC and GR were 65.40 ± 0.98, 67.41 ± 0.43, 72.81 ± 0.36, respectively. Statistical analysis revealed a significant difference (P<0.05) in dressing per centage among all three groups and higher dressing per centage was observed in GR followed by FNC and BNC.

4.1.4 Cut up parts yield (%)

The Mean ± SE of breast yield of BNC, FNC and GR were 24.79 ± 0.49, 26.13 ± 0.33 and 27.64 ± 0.55, respectively. A significant difference (P<0.05) was observed in breast yield among the groups, where in GR recorded the highest yield which was not significant from FNC. BNC recorded the lowest breast yield among the three groups.

The Mean ± SE of neck yield of BNC, FNC and GR were 5.945 ± 0.15, 5.078 ± 0.13 and 5.249 ± 0.17, respectively. Statistically, there was a significant difference (P<0.05) in neck yield among all three groups. Neck yield was higher BNC followed by GR and FNC.

The Mean ± SE of back yield of BNC, FNC and GR were 22.91 ± 0.32, 22.37 ± 0.39 and 20.44 ± 0.29, respectively. A significant difference (P<0.05) in back yield between BNC and GR and between FNC and GR was observed, whereas no significant (P>0.05) difference could be found between BNC and FNC. Back yield was higher in BNC followed by FNC and GR.

The Mean ± SE of wing yield of BNC, FNC and GR were 10.36 ± 0.29, 10.55 ± 0.23 and 12.64 ± 0.39, respectively. A significant difference (P<0.05) in wing yield between BNC and GR and between FNC and GR was evident, whereas no significant ($P>0.05$) difference could be observed between BNC and FNC. The wing yield was higher in GR followed by FNC and BNC.

The Mean ± SE of thigh yield of BNC, FNC and GR were 17.47 ± 0.33, 17.04 ± 0.22 and 18.96 ± 0.18, respectively. Statistically, there was a significant difference ($P<0.05$) in thigh yield between BNC and GR and between FNC and GR. There was no significant ($P>0.05$) difference between BNC and FNC.

The Mean ± SE of drumstick yield of BNC, FNC and GR were 16.29 ± 0.33, 16.05 ± 0.14 and 17.49 ± 0.24, respectively. Statistically, there was a significant difference ($P<0.05$) in thigh yield between BNC and GR and between FNC and GR. There was no significant ($P>0.05$) difference between BNC and FNC.

4.2 Physico- chemical characteristics of breast muscle

The Mean ± SE of pH, drip loss, cooking loss, water holding capacity, lightness, redness and yellowness values of breast muscle from Backyard Native Chicken, Farm reared Native Chicken and Giriraja are presented in the Table 4.2.

4.2.1 pH

The Mean ± SE of the pH_{45min} of BNC, FNC and GR breast muscle were 6.39 ± 0.045, 6.50 ± 0.025 and 6.49 ± 0.022, respectively. A significant difference ($P<0.05$) in pH_{45min} of breast muscle was observed between BNC and FNC, whereas no significant ($P>0.05$) difference could be observed between BNC and GR and between FNC and GR. Breast muscle from FNC had higher pH_{45min} as compared to GR and BNC.

Table 4.1: Carcass Characteristics of Backyard native chicken (BNC), Farm native chicken (FNC) and Giriraja (GR) chicken

Parameter	BNC	FNC	GR
Live weight (g)	1295 ± 45.00^{a}	1390 ± 35.00^{b}	1714 ± 28.17^{c}
Carcass weight (g)	847.8 ± 24.88^{a}	940.8 ± 24.89^{b}	1248 ± 21.31^{c}
Dressing percentage (%)	65.40 ± 0.98^{a}	67.41 ± 0.43^{b}	72.81 ± 0.36^{c}
Breast Yield (%)	24.79 ± 0.49^{a}	26.13 ± 0.33^{ab}	27.64 ± 0.55^{b}
Neck Yield (%)	5.945 ± 0.15^{a}	5.078 ± 0.13^{b}	5.249 ± 0.17^{c}
Back Yield (%)	22.91 ± 0.32^{a}	22.37 ± 0.39^{a}	20.44 ± 0.29^{b}
Wing Yield (%)	10.36 ± 0.29^{a}	10.55 ± 0.23^{a}	12.64 ± 0.39^{b}
Thigh Yield (%)	17.47 ± 0.33^{a}	17.04 ± 0.22^{a}	18.96 ± 0.18^{b}
Drumstick Yield (%)	16.29 ± 0.33^{a}	16.05 ± 0.14^{a}	17.49 ± 0.24^{b}

Mean ± SE bearing different superscripts between rows are statistically different at $P<0.05$

The Mean ± SE of the pH_{24hrs} of BNC, FNC and GR breast muscle were 6.01 ± 0.024, 6.00 ± 0.031 and 5.86 ± 0.030, respectively. A significant difference (P<0.05) in $pH_{24\ hrs}$ of breast muscle between BNC and GR and between FNC and GR was observed, with no significant (P>0.05) difference between BNC and FNC. Lower ultimate pH of breast muscle was recorded in GR as compared to BNC and FNC.

4.2.2 Water holding capacity (WHC)

The Mean ± SE of the WHC (%) of BNC, FNC and GR breast muscle were 13.49 ± 0.365, 13.37 ± 0.443 and 12.24 ± 0.496, respectively. Statistically, there was a significant difference (P<0.05) in WHC of breast muscle between BNC and GR and between FNC and GR. Breast muscle of BNC had higher WHC as compared to GR, however it was similar to that of FNC.

4.2.3 Drip loss (%)

The Mean ± SE of the drip loss of BNC, FNC and GR breast muscle were 1.53 ± 0.056, 1.55 ± 0.050 and 1.64 ± 0.069, respectively. No significant difference in drip loss was evident between BNC and FNC, whereas a significant difference (P<0.05) in drip loss of breast muscle was observed between BNC and GR and between FNC and GR. Drip loss was highest in breast muscles of GR compared to BNC and FNC.

4.2.4 Cooking loss (%)

The Mean ± SE of the cooking loss (%) of BNC, FNC and GR breast muscle were 9.43 ± 0.584, 10.10 ± 0.288 and 13.94 ± 0.801, respectively. GR recorded a statistically

(P<0.05) higher cooking loss as compared to BNC and FNC, which had similar cooking losses.

4.2.5 Instrumental colour

4.2.5.1 Lightness (L*)

The Mean ± SE of the L* values of BNC, FNC and GR breast muscle were 49.57 ± 0.711, 50.67 ± 0.821 and 54.67 ± 0.523, respectively. Statistically, there was a significant difference (P<0.05) in L* of breast muscle between BNC and GR and between FNC and GR, whereas there was no significant (P>0.05) difference between BNC and FNC. L* of breast meat showed higher value in GR followed by FNC and BNC.

4.2.5.2 Redness (a*)

The Mean ± SE of a* value of BNC, FNC and GR breast muscle were 2.80 ± 0.126, 2.61 ± 0.120 and 1.61 ± 0.059, respectively. A significant difference (P<0.05) in a* value was observed between BNC and GR and between FNC and GR, whereas no significant (P>0.05) difference was evident BNC and FNC. BNC and FNC had higher a* value compared to GR.

4.2.5.3 Yellowness (b*)

The Mean ± SE of b* value of BNC, FNC and GR were 10.91 ± 0.183, 10.32 ± 0.201 and 10.03 ± 0.235, respectively. A significant difference (P<0.05) was observed in b* value between BNC and GR, whereas no significant (P>0.05) difference between BNC and FNC and between FNC and GR was evident. BNC had higher yellowness followed by FNC and GR.

Table 4.2: Physico-chemical characteristics of breast muscle from Backyard native chicken (BNC), Farm native chicken (FNC) and Giriraja (GR) chicken

Parameter	BNC	FNC	GR
$pH_{45\ mins}$	6.39 ± 0.045^{a}	6.50 ± 0.025^{b}	6.49 ± 0.022^{ab}
$pH_{24\ hrs}$	6.01 ± 0.024^{a}	6.00 ± 0.031^{a}	5.86 ± 0.030^{b}
WHC (%)	13.49 ± 0.365^{a}	13.37 ± 0.443^{a}	12.24 ± 0.496^{b}
Drip loss (%)	1.53 ± 0.056^{a}	1.55 ± 0.050^{a}	1.64 ± 0.069^{b}
Cooking loss (%)	9.43 ± 0.584^{a}	10.10 ± 0.288^{a}	13.94 ± 0.801^{b}
Colour			
L*	49.57 ± 0.711^{a}	50.67 ± 0.821^{a}	54.67 ± 0.523^{b}
a*	2.80 ± 0.126^{a}	2.61 ± 0.120^{a}	1.61 ± 0.0590^{b}
b*	10.91 ± 0.183^{a}	10.32 ± 0.201^{ab}	10.03 ± 0.235^{b}

Mean ± SE bearing different superscripts are statistically different at P<0.05

4.3 Structural characteristics

The Mean ± SE of shear force, collagen content, muscle fibre diameter and sarcomere length of breast muscle from Backyard Native Chicken (BNC), Farm reared Native Chicken and Giriraja are presented in the Table 4.3.

4.3.1 Shear force (kg/cm^2)

The Mean ± SE of shear-force of BNC, FNC and GR were 5.89 ± 0.091, 5.01 ± 0.132 and 4.84 ± 0.087, respectively. A significant difference ($P<0.05$) between BNC and FNC and between BNC and GR was observed, whereas no significant ($P>0.05$) difference was evident between FNC and GR. BNC had higher Shear force value followed by FNC and the lowest value being recorded in GR.

4.3.2 Collagen content (mg/100g)

The Mean ± SE of collagen content of BNC, FNC and GR were 489.1 ± 7.682, 403.2 ± 7.781 and 361.3 ± 8.838, respectively. A significant difference ($P<0.05$) was observed in collagen content among all three groups, with higher collagen content reported in BNC followed by FNC and GR.

4.3.3 Muscle fibre diameter (µm) and Sarcomere length (µm)

The Mean ± SE of muscle fibre of BNC, FNC and GR were 58.52 ± 1.805, 50.30 ± 1.888 and 42.88 ± 2.370, respectively and sarcomere length (SL) were 1.29 ± 0.044, 1.42 ± 0.049 and 1.51 ± 0.064, respectively. A significant difference ($P<0.05$) in MFD was observed among all three groups, whereas a significant difference ($P<0.05$) between BNC and GR was evident in sarcomere length. No significant ($P>0.05$) difference was observed between BNC and FNC and between FNC and GR in SL. Sarcomere length was higher in GR, whereas BNC had higher MFD compared to other groups.

Table 4.3: Structural characteristics of breast muscle from Backyard native chicken (BNC), Farm native chicken (FNC) and Giriraja (GR) chicken

Parameter	BNC	FNC	GR
Shear force value (kg/cm^2)	5.89 ± 0.091^b	5.01 ± 0.132^a	4.84 ± 0.087^a
Collagen content (mg/100g)	489.1 ± 7.682^a	403.2 ± 7.781^b	361.3 ± 8.838^c
Muscle fibre diameter (µm)	58.52 ± 1.805^a	50.30 ± 1.888^b	42.88 ± 2.370^c
Sarcomere length (µm)	1.29 ± 0.044^a	1.42 ± 0.049^{ab}	1.51 ± 0.064^b

Mean ± SE bearing different superscripts are statistically different at P<0.05

4.4 PROXIMATE COMPOSITION

The Mean ± SE of moisture, protein, fat, ash, energy, carbohydrate, cholesterol of breast muscle from Backyard Native Chicken (BNC), Farm reared Native Chicken and Giriraja are presented in the Table 4.4.

4.4.1 Moisture (%)

The Mean ± SE of moisture of BNC, FNC and GR were 75.88 ± 0.322, 74.36 ± 0.275 and 71.34 ± 0.291, respectively. Statistically, there were significant differences (P<0.05) in moisture content among all three groups with higher moisture being reported in BNC followed by FNC and GR.

4.4.2 Protein (%)

The Mean ± SE of protein of BNC, FNC and GR were 20.02 ± 0.303, 20.91 ± 0.188 and 21.49 ± 0.335, respectively. A significant difference ($P<0.05$) in protein was evident between BNC and GR, whereas no significant ($P>0.05$) difference between BNC and FNC and between FNC and GR was evident. GR had higher protein content than FNC and BNC.

4.4.3 Fat (%)

The Mean ± SE of the fat of BNC, FNC and GR breast muscle were 0.95 ± 0.037, 1.233 ± 0.106 and 5.87 ± 0.089, respectively. A significant difference ($P<0.05$) in fat content was evident between BNC and GR and between FNC and GR. However, no significant ($P>0.05$) difference was observed in fat content between BNC and FNC. Breast muscle from GR had higher fat as compared to other groups.

4.4.4 Ash (%)

The Mean ± SE of the ash of BNC, FNC and GR breast muscle were 1.42 ± 0.088, 2.25 ± 0.129 and 2.29 ± 0.105, respectively. A significant difference ($P<0.05$) in ash content was recorded between BNC and FNC and between BNC and GR. GR recorded higher ash content followed by FNC and BNC.

4.4.5 Carbohydrate (g/100g)

The Mean ± SE of the carbohydrate of BNC, FNC and GR were 2.09 ± 0.045, 2.50 ± 0.028 and 2.53 ± 0.033, respectively. A significant difference ($P<0.05$) in carbohydrate was observed between BNC and FNC and between BNC and GR. No significant ($P>0.05$) difference in carbohydrate was established between FNC and GR.

4.4.6 Cholesterol (mg/100g)

The Mean ± SE of the cholesterol of BNC, FNC and GR were 35.83 ± 1.648, 36.17 ± 1.829 and 78.57 ± 4.026, respectively. A significant difference (P<0.05) in cholesterol content was observed between BNC and GR and between FNC and GR in breast muscle, whereas no significant (P>0.05) difference could be established between BNC and FNC. GR had highest cholesterol content among all the three groups studied.

4.4.7 Energy (kcal/100g)

The Mean ± SE of energy of BNC, FNC and GR were 96.94 ± 1.333, 105.9 ± 0.786 and 145.5 ± 0.995, respectively. A significant difference (P<0.05) in energy was evident among all three groups and higher energy values were reported in GR followed by FNC and BNC.

Table 4.4: Proximate composition of breast muscle from Backyard native chicken (BNC), Farm native chicken (FNC) and Giriraja (GR) chicken

Parameter	BNC	FNC	GR
Moisture	75.88 ± 0.322^{a}	74.36 ± 0.275^{b}	71.34 ± 0.291^{c}
Protein	20.02 ± 0.303^{a}	20.91 ± 0.188^{ab}	21.49 ± 0.335^{b}
Fat	0.95 ± 0.037^{a}	1.23 ± 0.106^{a}	5.87 ± 0.089^{b}
Ash	1.42 ± 0.088^{a}	2.25 ± 0.129^{b}	2.29 ± 0.105^{b}
Carbohydrates	2.09 ± 0.045^{a}	2.50 ± 0.028^{b}	2.53 ± 0.033^{b}
Cholesterol	35.83 ± 1.648^{a}	36.17 ± 1.829^{a}	78.57 ± 4.026^{b}
Energy	96.94 ± 1.333^{a}	105.9 ± 0.786^{b}	145.5 ± 0.995^{c}

Mean ± SE bearing different superscripts are statistically different at P<0.05

4.5 Sensory Characteristics

The Mean ± SE of appearance, flavour, juiciness, tenderness and overall acceptability scores of breast muscle from Backyard Native Chicken (BNC), Farm reared Native Chicken and Giriraja breast muscle are presented in the Table 4.5.

4.5.1 Appearance score

The Mean ± SE of appearance scores of BNC, FNC and GR were 6.81 ± 0.046, 6.78 ± 0.050 and 6.93 ± 0.048, respectively. Statistically, there was no significant difference in appearance among all three groups, however, BNC recorded higher appearance as compared to FNC and GR.

4.5.2 Flavour score

The Mean ± SE of flavour scores of BNC, FNC and GR were 6.98 ± 0.069, 6.95 ± 0.056 and 6.80 ± 0.046 respectively. No significant differences in flavour scores could be observed between all three groups, however BNC recorded the highest flavour scores among all the three groups.

4.5.3 Juiciness score

The Mean ± SE of the juiciness scores of BNC, FNC and GR breast muscle were 6.46 ± 0.051, 6.58 ± 0.049 and 6.80 ± 0.046, respectively. Statistically, there was a significant difference ($P<0.05$) in juiciness of breast muscle between BNC and GR and between FNC and GR. There was no significant difference between BNC and FNC. GR had higher scores for juiciness followed by FNC and BNC.

4.5.4 Tenderness score

The Mean ± SE of the tenderness scores of BNC, FNC and GR breast muscle were 6.08 ± 0.067, 6.17 ± 0.067 and 6.70 ± 0.052, respectively. Statistically, there was a significant difference (P<0.05) in tenderness of breast muscle between BNC and GR and between FNC and GR. There was no significant (P>0.05) difference between BNC and FNC. GR had higher tenderness scores for breast muscle compared to FNC and BNC.

4.5.5 Overall acceptability score

The Mean ± SE of the overall acceptability scores of BNC, FNC and GR breast muscle were 6.53 ± 0.083, 6.51 ± 0.055 and 7.30 ± 0.045, respectively. A significant difference (P<0.05) in overall acceptability of breast muscle was evident between BNC and GR and between FNC and GR. However, no significant (P>0.05) difference was observed between BNC and FNC. GR recorded the highest overall acceptability scores by the panellist compared to FNC and BNC.

Table 4.5: Sensory characteristics of breast muscle from Backyard native chicken (BNC), Farm native chicken (FNC) and Giriraja (GR) chicken

Parameter	BNC	FNC	GR
Appearance score	6.81 ± 0.046	6.78 ± 0.050	6.93 ± 0.048
Flavor score	6.98 ± 0.069	6.95 ± 0.056	6.80 ± 0.046
Juiciness score	6.46 ± 0.051^{a}	6.58 ± 0.049^{a}	6.80 ± 0.046^{b}
Tenderness	6.08 ± 0.067^{a}	6.17 ± 0.067^{a}	6.70 ± 0.052^{b}
Overall acceptability score	6.53 ± 0.083^{a}	6.51 ± 0.055^{a}	7.30 ± 0.045^{b}

Mean ± SE bearing different superscripts are statistically different at P<0.05

4.6 Physico-chemical characteristics of thigh muscle

The Mean ± SE of pH, drip loss, cooking loss, water holding capacity, lightness, redness and yellowness of thigh muscle from Backyard Native Chicken (BNC), Farm reared Native Chicken and Giriraja are presented in the Table 4.6.

4.6.1 pH

The Mean ± SE of the pH_{45min} of BNC, FNC and GR thigh muscle were 6.46 ± 0.022, 6.56 ± 0.031 and 6.39 ± 0.043, respectively. A significant difference ($P<0.05$) in pH_{45min} of thigh muscle was observed between FNC and GR. There was no significant ($P>0.05$) difference between BNC and FNC and between BNC and GR.

The Mean ± SE of the pH_{24h} of BNC, FNC and GR thigh muscle were 5.96 ± 0.025, 5.89 ± 0.029 and 5.85 ± 0.030, respectively. Statistically, there was a significant difference ($P<0.05$) in pH_{24h} of thigh muscle between BNC and GR and between FNC and GR. There was no significant ($P>0.05$) difference between BNC and FNC.

4.6.2 WHC (%)

The Mean ± SE of the WHC of BNC, FNC and GR thigh muscle were 12.22 ± 0.317, 11.95 ± 0.395 and 12.05 ± 0.897, respectively. A significant difference ($P<0.05$) in WHC of thigh muscle was evident between BNC and FNC and between FNC and GR, whereas there was no significant ($P>0.05$) difference between BNC and GR.

4.6.3 Drip loss (%)

The Mean ± SE of the drip loss of BNC, FNC and GR thigh muscle were 1.60 ± 0.052, 1.65 ± 0.045 and 1.80 ± 0.064, respectively. No significant difference was observed between BNC and FNC and between FNC and GR, whereas a significant difference ($P<0.05$) in drip loss was evident between BNC and GR. Drip loss was higher in GR as compared to BNC and FNC.

4.6.4 Cooking loss (%)

The Mean ± SE of the cooking loss of BNC, FNC and GR thigh muscle were 17.52 ± 1.147, 17.78 ± 0.301 and 19.93 ± 0.817, respectively. Statistically, there was a significant difference ($P<0.05$) in cooking loss of thigh meat between BNC and GR and between FNC and GR.

4.6.5 Instrumental colour

The Mean ± SE of the L* of BNC, FNC and GR thigh meat were 46.81 ± 1.030, 48.07 ± 1.005 and 53.94 ± 1.160, respectively, a* values were 5.31 ± 0.112, 4.50 ± 0.097 and 2.43 ± 0.078, respectively and b* values were 11.68 ± 0.328, 11.76 ± 0.332 and 13.55 ± 0.573, respectively. A significant difference ($P<0.05$) in L*, a* and b* values of thigh muscle was observed between BNC and GR and between FNC and GR. However, no significant ($P>0.05$) difference could be observed between BNC and FNC in all the colour values.

Thigh muscle from GR had the higher L* and b* values, whereas the thigh muscle of BNC and FNC had higher a* values compared to the other groups.

Table 4.6: Physico-chemical characteristics of thigh meat from Backyard native chicken (BNC), Farm native chicken (FNC) and Giriraja (GR) chicken

Parameter	BNC	FNC	GR
$pH_{45\ min}$	6.46 ± 0.022^{ab}	6.56 ± 0.031^{a}	6.39 ± 0.043^{b}
$pH_{24\ h}$	5.96 ± 0.025^{a}	5.89 ± 0.029^{a}	5.85 ± 0.030^{b}
WHC	12.22 ± 0.317^{a}	11.95 ± 0.395^{b}	12.05 ± 0.897^{a}
Drip loss	1.60 ± 0.052^{a}	1.65 ± 0.045^{ab}	1.80 ± 0.064^{b}
Cooking loss	17.52 ± 1.147^{a}	17.78 ± 0.301^{a}	19.93 ± 0.817^{b}
Colour			
L*	46.81 ± 1.030^{a}	48.07 ± 1.005^{a}	53.94 ± 1.160^{b}
a*	5.31 ± 0.112^{a}	4.50 ± 0.097^{a}	2.43 ± 0.078^{b}
b*	11.68 ± 0.328^{a}	11.76 ± 0.332^{a}	13.55 ± 0.573^{b}

Note: Mean ± SE bearing different superscripts are statistically different at $P<0.05$

4.7 Structural characteristics

The Mean ± SE of shear force, collagen content, muscle fibre diameter and sarcomere length of thigh muscle from Backyard Native Chicken (BNC), Farm reared Native Chicken and Giriraja are presented in the Table 4.7.

4.7.1 Shear force values (Kg/cm^2)

The Mean ± SE of the SFV of BNC, FNC and GR thigh muscle were 5.93 ± 0.123, 5.84 ± 0.104 and 5.29 ± 0.050, respectively. Statistical analysis revealed a significant difference ($P<0.05$) in SFV of thigh muscle between BNC and GR and between FNC and GR. However, there was no significant ($P>0.05$) difference between BNC and FNC. SFV of thigh muscle from BNC had higher shear value followed by FNC and GR.

4.7.2 Collagen content (mg/100g)

The Mean ± SE of the collagen content of BNC, FNC and GR thigh muscle were 503.6 ± 30.42, 456.6 ± 22.34 and 378.6 ± 16.88, respectively. A significant difference ($P<0.05$) in collagen content was observed between BNC and GR, whereas no significant ($P>0.05$) difference was evident in collagen content between BNC and FNC and between FNC and GR. Collagen content was higher in thigh muscle from BNC and the lowest was recorded in GR.

4.7.3 Muscle fibre diameter (μm)

The Mean ± SE of the muscle fibre diameter of BNC, FNC and GR thigh muscle were 59.64 ± 1.920, 54.57 ± 2.321 and 50.49 ± 2.852, respectively. A significant difference ($P<0.05$) in muscle fibre diameter of thigh muscle was observed between BNC and GR, whereas no significant (P>0.05) difference was recorded between BNC and FNC and between FNC and GR. Thigh muscles from BNC recorded the highest muscle fibre diameter.

4.7.4 Sarcomere length (µm)

The Mean ± SE of the sarcomere length of BNC, FNC and GR thigh muscle were 1.44 ± 0.038, 1.54 ± 0.036 and 1.79 ± 0.043, respectively. Test of significance revealed a significant difference (P<0.05) in sarcomere length between BNC and GR and between FNC and GR. However, no significant (P>0.05) difference was observed between BNC and FNC. Higher sarcomere length of thigh muscle was recorded in GR followed by FNC and BNC.

Table 4.7: Structural characteristics of thigh muscle from Backyard native chicken (BNC), Farm native chicken (FNC) and Giriraja (GR) chicken

Parameter	BNC	FNC	GR
Shear force value (kg/cm^2)	5.93 ± 0.123^a	5.84 ± 0.104^a	5.29 ± 0.050^b
Collagen content (mg/100g)	503.6 ± 30.42^a	456.6 ± 22.34^{ab}	378.6 ± 16.88^b
Muscle fibre diameter (µm)	59.64 ± 1.920^a	54.57 ± 2.321^{ab}	50.49 ± 2.852^b
Sarcomere length (µm)	1.44 ± 0.038^a	1.54 ± 0.036^a	1.79 ± 0.043^b

Mean ± SE bearing different superscripts are statistically different at P<0.05

4.8 Proximate composition

The Mean ± SE of moisture, protein, fat, ash, energy, carbohydrate, cholesterol of thigh muscle from Backyard Native Chicken (BNC), Farm reared Native Chicken and Giriraja are presented in the Table 4.8.

4.8.1 Moisture (%)

The Mean ± SE of the moisture of BNC, FNC and GR thigh muscle were 78.38 ± 0.492, 78.35 ± 0.092 and 69.90 ± 0.496, respectively. A significant difference ($P<0.05$) in moisture content of thigh muscle was observed between BNC and GR and between FNC and GR, whereas there was no significant difference between BNC and FNC. BNC thigh muscle recorded higher moisture content compared to other groups.

4.8.2 Protein (%)

The Mean ± SE of the protein of BNC, FNC and GR thigh muscle were 17.85 ± 0.402, 18.19 ± 0.163 and 20.02 ± 0.224, respectively. A significant difference ($P<0.05$) in protein content of thigh muscle was evident between BNC and GR and between FNC and GR. However no significant ($P>0.05$) difference was recorded between BNC and FNC. GR thigh muscles had higher protein content.

4.8.3 Fat (%)

The Mean ± SE of the fat of BNC, FNC and GR thigh muscle were 1.98 ± 0.190, 2.32 ± 0.091 and 7.49 ± 0.770, respectively. A significant difference ($P<0.05$) in fat of thigh muscle was observed between BNC and GR and between FNC and GR, whereas there was no significant ($P>0.05$) difference in fat between BNC and FNC. Thigh muscle from GR had higher fat content.

4.8.4 Ash (%)

The Mean ± SE of the ash of BNC, FNC and GR thigh muscle were 1.45 ± 0.050, 1.49 ± 0.040 and 2.60 ± 0.517, respectively. Statistically, there was a significant difference

(P<0.05) in ash of thigh muscle between BNC and GR and between FNC and GR. No significant (P>0.05) difference was evident between BNC and FNC.

4.8.5 Carbohydrates (g/100g)

The Mean ± SE of the carbohydrate of BNC, FNC and GR thigh muscle were 0.65 ± 0.021, 0.64 ± 0.049 and 2.90 ± 0.517, respectively. A significant difference (P<0.05) in carbohydrate of thigh muscle between BNC and GR and between FNC and GR was observed, whereas no significant (P>0.05) difference was evident between BNC and FNC.

4.8.6 Cholesterol (mg/100g)

The Mean ± SE of cholesterol of BNC, FNC and GR were 45.38 ± 4.221, 66.07 ± 9.982 and 64.01 ± 5.321. A significant difference (P<0.05) in cholesterol content was observed with lowest cholesterol being recorded in BNC and no significant difference could be observed between FNC and GR.

4.8.7 Energy (kcal/100g)

The Mean ± SE of energy of BNC, FNC and GR were 94.84 ± 2.099, 93.11 ± 1.143 and 160.2 ± 5.459. Statistically, there was a significant difference (P<0.05) in energy of thigh muscle between BNC and GR and between FNC and GR. However, no significant (P>0.05) difference was evident between BNC and FNC. Higher energy content was recorded in thigh muscle from GR.

Table 4.8: Proximate composition of thigh meat from Backyard native chicken (BNC), Farm native chicken (FNC) and Giriraja (GR) chicken

Parameter	BNC	FNC	GR
Moisture	78.38 ± 0.492^{a}	78.35 ± 0.092^{a}	69.90 ± 0.496^{b}
Protein	17.85 ± 0.402^{a}	18.19 ± 0.163^{a}	20.02 ± 0.224^{b}
Fat	1.98 ± 0.190	2.32 ± 0.091^{a}	7.49 ± 0.770^{b}
Ash	1.45 ± 0.050^{a}	1.49 ± 0.040^{a}	2.60 ± 0.307^{b}
Carbohydrates	0.65 ± 0.021^{a}	0.64 ± 0.049^{a}	2.90 ± 0.517^{b}
Cholesterol	45.38 ± 4.221^{a}	66.07 ± 9.982^{b}	64.01 ± 5.321^{b}
Energy	94.84 ± 2.099^{a}	93.11 ± 1.143^{a}	160.2 ± 5.459^{b}

Mean ± SE bearing different superscripts are statistically different at $P<0.05$

4.9 Sensory characteristics

The Mean ± SE of appearance, flavour, juiciness, tenderness and overall acceptability scores of thigh muscle from Backyard Native Chicken (BNC), Farm reared Native Chicken and Giriraja are presented in the Table 4.9.

4.9.1 Appearance score

The Mean ± SE of appearance score of BNC, FNC and GR were 6.78 ± 0.040, 6.82 ± 0.039 and 7.11 ± 0.056. A significant difference ($P<0.05$) in appearance scores of thigh muscle was observed between BNC and GR and between FNC and GR, whereas no significance ($P>0.05$) was evident between BNC and FNC.

4.9.2 Flavour score

The Mean ± SE of flavour scores of BNC, FNC and GR were 7.17 ± 0.037, 6.92 ± 0.060 and 6.55 ± 0.043, respectively. A significant difference ($P<0.05$) in flavour scores was observed between all three groups and higher flavour value was reported in BNC followed by FNC and GR.

4.9.3 Juiciness score

The Mean ± SE of juiciness scores of BNC, FNC and GR were 6.33 ± 0.046, 6.44 ± 0.052 and 7.20 ± 0.045, respectively. Statistically, there was a significant difference ($P<0.05$) in juiciness of thigh muscle between BNC and GR and between FNC and GR. Thigh muscles of GR had higher juiciness scores as compared to FNC and BNC.

4.9.4 Tenderness score

The Mean ± SE of tenderness scores of BNC, FNC and GR were 6.11 ± 0.071, 6.43 ± 0.092 and 6.93 ± 0.046, respectively. Statistically, there were significant differences ($P<0.05$) in tenderness values among all three groups and higher tenderness value was reported in GR followed by FNC and BNC.

4.9.5 Overall acceptability score

The Mean ± SE of overall acceptability scores of BNC, FNC and GR were 6.53 ± 0.052, 6.65 ± 0.069 and 7.32 ± 0.051, respectively. Statistically, there was a significant difference ($P<0.05$) in overall acceptability of thigh muscle between BNC and GR and between FNC and GR. Overall acceptability of thigh muscle of GR was higher compared to FNC and BNC.

Table 4.9: Sensory characteristics of thigh meat from Backyard native chicken (BNC), Farm native chicken (FNC) and Giriraja (GR) chicken

Parameter	BNC	FNC	GR
Appearance score	6.78 ± 0.040^{a}	6.82 ± 0.039^{a}	7.11 ± 0.056^{b}
Flavor score	7.17 ± 0.037^{a}	6.92 ± 0.060^{b}	6.55 ± 0.043^{c}
Juiciness score	6.33 ± 0.046^{a}	6.44 ± 0.052^{a}	7.20 ± 0.045^{b}
Tenderness score	6.11 ± 0.071^{a}	6.43 ± 0.092^{b}	6.93 ± 0.046^{c}
Overall acceptability score	6.53 ± 0.052^{a}	6.65 ± 0.069^{a}	7.32 ± 0.051^{b}

Mean ± SE bearing different superscripts are statistically different at $P<0.05$

4.10 Comparison of thigh and breast muscle

The Mean ± SE of physico-chemical characteristics, structural characteristics, proximate composition and organoleptic attributes values of BNC, FNC and GR breast and thigh muscles are depicted in the Table 4.10, Table 4.11 and Table 4.12, respectively.

4.10.1 Backyard native Chicken (BNC)

A highly significant ($P<0.01$) difference in cooking loss and redness and a significant ($P<0.05$) difference ultimate pH, WHC, lightness and yellowness were observed between breast and thigh muscles of backyard native chicken. However, there were no significant ($P>0.05$) differences in pH_{45min} and drip loss between breast and thigh muscles of backyard native chicken. Thigh muscle had lower pH_{24h}, water holding capacity and lightness value compared to breast muscle, whereas thigh muscle had higher cooking loss, redness and yellowness as compared to breast muscle of backyard native chicken.

A significant difference ($P<0.05$) was observed in sarcomere length between breast and thigh muscles, with later having a higher value, whereas, no significant difference ($P>0.01$) was observed in shear force, collagen content and muscle fibre diameter between breast and thigh muscles. A highly significant difference was observed in moisture, protein, fat, cholesterol and carbohydrate, whereas, no significant difference ($P>0.01$) was observed in ash and energy between breast and thigh muscles. Higher content of protein, energy and carbohydrate was observed in breast muscle and higher content of moisture, fat, ash and cholesterol were recorded in thigh muscles.

Table 4.10: Comparison of physico-chemical, structural, compositional and sensory characteristics of thigh and breast muscle of backyard native chicken (BNC)

Parameters	Breast	Thigh	Significance
$pH_{45\ mins}$	6.39 ± 0.045	6.46 ± 0.022	NS
$pH_{24\ hrs}$	6.01 ± 0.024	5.96 ± 0.025	*
WHC (%)	13.49 ± 0.365	12.22 ± 0.317	*
Drip loss	1.53 ± 0.056	1.60 ± 0.052	NS
Cooking loss	9.43 ± 0.584	17.52 ± 1.147	**
L*	49.57 ± 0.711	46.81 ± 1.030	*
a*	2.80 ± 0.126	5.31 ± 0.112	**
b*	10.91 ± 0.183	11.68 ± 0.328	*
Shear force value	5.89 ± 0.091	5.93 ± 0.123	NS
Collagen content	489.1 ± 7.682	503.6 ± 30.42	NS
Muscle fibre diameter	58.52 ± 1.805	59.64 ± 1.920	NS
Sarcomere length	1.289 ± 0.044	1.44 ± 0.038	*
Moisture	75.88 ± 0.322	78.38 ± 0.492	**
Protein	20.02 ± 0.303	17.85 ± 0.402	**
Fat	0.95 ± 0.037	1.98 ± 0.190	**
Ash	1.42 ± 0.088	1.45 ± 0.050	NS
Cholesterol	35.83 ± 1.648	45.38 ± 4.221	**
Carbohydrate	2.09 ± 0.045	0.65 ± 0.021	**
Energy	96.94 ± 1.333	94.84 ± 2.099	NS
Appearance	6.81 ± 0.046	6.78 ± 0.040	NS
Flavour	6.98 ± 0.069	7.17 ± 0.037	*
Juiciness	6.46 ± 0.051	6.33 ± 0.046	NS
Tenderness	6.08 ± 0.067	6.11 ± 0.071	NS
Overall acceptability	6.53 ± 0.083	6.53 ± 0.052	NS

Sensory analysis revealed a significant difference ($P<0.05$) in flavor with higher scores for thigh meat, whereas no significant difference ($P>0.01$) was evident in appearance, juiciness, tenderness and overall acceptability between breast and thigh muscles.

4.10.2 Farm native chicken (FNC)

Analysis of physico-chemical characteristics revealed a highly significant ($P<0.01$) difference in cooking loss, redness and yellowness and significant ($P<0.05$) difference in pH_{24h}, WHC and lightness between breast and thigh muscles of farm native chicken. However, there were no significant ($P>0.05$) differences in pH_{45min} and drip loss between breast and thigh muscles of farm native chicken. Thigh muscles had lower ultimate pH, WHC and L* value and higher cooking loss, a* and b* value compared to breast muscle in farm native chicken.

A highly significant ($P<0.01$) difference in shear force value and a significant difference ($P<0.05$) in collagen content was observed, whereas no significant difference ($P>0.01$) was observed in muscle fibre diameter and sarcomere length between breast and thigh muscles. Higher shear force, collagen content, muscle fibre diameter and sarcomere length was evident in thigh muscle than breast muscle.

A highly significant ($P<0.01$) difference in moisture, protein, fat, cholesterol, energy and carbohydrate were observed, whereas no significant difference ($P>0.01$) was observed in ash between breast and thigh muscles. Breast muscle had higher protein, energy, ash and carbohydrate, whereas thigh muscle had higher moisture, fat and cholesterol as compared to breast muscle.

Table 4.11: Comparison of physico-chemical, structural, compositional and sensory characteristics of thigh and breast muscle of farm reared native chicken (FNC)

Parameters	Breast	Thigh	Significance
$pH_{45\ mins}$	6.50 ± 0.025	6.46 ± 0.022	NS
$pH_{24\ hrs}$	6.00 ± 0.031	5.96 ± 0.025	*
WHC (%)	13.37 ± 0.443	12.22 ± 0.317	*
Drip loss	1.55 ± 0.050	1.60 ± 0.052	NS
Cooking loss	10.10 ± 0.288	17.52 ± 1.147	**
L*	50.67 ± 0.821	46.81 ± 1.030	*
a*	2.61 ± 0.120	5.31 ± 0.112	**
b*	10.32 ± 0.201	11.68 ± 0.328	**
Shear force value	5.01 ± 0.132	5.84 ± 0.104	NS
Collagen content	403.2 ± 7.781	456.6 ± 22.34	NS
Muscle fibre diameter	50.30 ± 1.888	54.57 ± 2.321	NS
Sarcomere length	1.423 ± 0.049	1.54 ± 0.036	*
Moisture	75.88 ± 0.322	78.35 ± 0.092	**
Protein	20.02 ± 0.303	18.19 ± 0.163	**
Fat	0.95 ± 0.037	2.32 ± 0.091	**
Ash	1.42 ± 0.088	1.49 ± 0.040	NS
Cholesterol	35.83 ± 1.648	66.07 ± 9.982	**
Carbohydrate	2.09 ± 0.045	0.64 ± 0.049	**
Energy	96.94 ± 1.333[a]	93.11 ± 1.143	**
Appearance	6.78 ± 0.050	6.82 ± 0.039	NS
Flavour	6.95 ± 0.056	6.92 ± 0.060	NS
Juiciness	6.58 ± 0.049	6.44 ± 0.052	NS
Tenderness	6.17 ± 0.067	6.43 ± 0.092	*
Overall acceptability	6.51 ± 0.055	6.65 ± 0.069	NS

A significant difference (P<0.05) in tenderness was evident with thigh muscle having higher tenderness scores, whereas no significant difference (P>0.01) in appearance, flavour, juiciness and overall acceptability was evident between breast and thigh muscles of farm reared native chicken.

4.10.3 Giriraja chicken (GR)

Comparison of thigh and breast muscle of Giriraja chicken it was observed that a highly significant (P<0.01) difference in cooking loss, redness and yellowness and significant (P<0.05) difference in pH_{45min} and pH_{24h}. However, no significant (P>0.05) differences in WHC, drip loss and lightness were observed. Lower initial and final pH was evident in thigh muscle as compared to breast muscle, whereas thigh muscles had higher cooking loss, redness and yellowness values.

A highly significant difference in (P<0.01) shear force, sarcomere length and a significant difference in muscle fibre diameter was observed between breast and thigh muscles. Higher values were observed in shear force, collagen content, muscle fibre diameter and sarcomere length of thigh muscle than breast muscle.

A highly significant (P<0.01) difference in fat and energy and protein and a significant difference (P<0.05) in cholesterol was observed between breast and thigh muscles. No significant difference (P>0.01) could be appreciated in ash and carbohydrate content between the muscles. Breast muscle has higher protein and cholesterol, whereas thigh muscle had higher content of moisture, fat, ash, energy and carbohydrate.

A significantly higher (P<0.01) juiciness, tenderness and appearance (P<0.05) was observed in the thigh muscle of GR as compared to breast, whereas no significant difference was observed in flavour and overall acceptability between breast and thigh muscles.

Table 4.12: Comparison of physico-chemical, structural, compositional and sensory characteristics of thigh and breast muscle of Giriraja chicken (GR)

Parameters	Breast	Thigh	Significance
$pH_{45\ mins}$	6.49 ± 0.022	6.39 ± 0.043	*
$pH_{24\ hrs}$	5.86 ± 0.030	5.85 ± 0.030	*
WHC (%)	12.24 ± 0.496	12.05 ± 0.897	NS
Drip loss	1.64 ± 0.069	1.80 ± 0.064	NS
Cooking loss	13.94 ± 0.801	19.93 ± 0.817	**
L*	54.67 ± 0.523	53.94 ± 1.160	NS
a*	1.61 ± 0.0590	2.43 ± 0.078	**
b*	10.03 ± 0.235	13.55 ± 0.573	**
Shear force value	4.84 ± 0.087	5.29 ± 0.050	**
Collagen content	361.3 ± 8.838	378.6 ± 16.88	NS
Muscle fibre diameter	42.88 ± 2.370	50.49 ± 2.852	*
Sarcomere length	1.513 ± 0.064	1.79 ± 0.043	**
Moisture	71.34 ± 0.291	69.90 ± 0.496	*
Protein	21.49 ± 0.335	20.02 ± 0.224	*
Fat	5.87 ± 0.089	7.49 ± 0.770	**
Ash	2.29 ± 0.105	2.60 ± 0.307	NS
Cholesterol	78.57 ± 4.026	64.01 ± 5.321	*
Carbohydrate	2.53 ± 0.033	2.90 ± 0.517	**
Energy	145.5 ± 0.995	160.2 ± 5.459	NS
Appearance	6.93 ± 0.048	7.11 ± 0.056	*
Flavour	6.80 ± 0.046	6.55 ± 0.043	NS
Juiciness	6.80 ± 0.046	7.20 ± 0.045	**
Tenderness	6.70 ± 0.052	6.93 ± 0.046	**
Overall acceptability	7.30 ± 0.045	7.32 ± 0.051	NS

Discussion

V. DISCUSSION

In the recent past there has been a consistent increase in the demand for meat from native or desi chicken due to its meat flavour, texture, quality and consumer preference. However, these birds under the existing backyard/ extensive system of rearing are slow growing, lower in productivity and weigh around 1.0-1.5 kg at around 6 months of age. Hence, meeting the increasing demand for native chicken meat under the existing system of rearing has been a great challenge for poultry producers and processors. To bridge the gap between demand and quality of meat from desi/ native chicken, producers and farmers have now entered into intensive system of rearing like that of broiler farming in urban and peri-urban areas in the recent past. Many producers have established small scale farms and have started rearing native chicken breeds like Aseel and Kadaknath for meat purpose and are realizing premium price for their produce. This intensive system of rearing of native chicken under farm conditions with commercial diets has drastically improved weight gain, feed efficiency and productivity. Quality traits of chicken meat along with nutritional compositions are mainly dependent upon animal genetics, feeding source, rearing systems, handling and slaughter techniques. Hence, changes in feeding and rearing practices would have major impact on the quality of meat produced from farm reared native breeds of chicken. Hence, it is imperative that studies need to be carried out to assess the impact of such intensive farming system on meat quality characteristics of native chicken before propagation of such practices. Hence, the present study has been undertaken to compare the carcass and meat quality characteristics of backyard native, farm reared native and Giriraja (dual purpose meat breed propagated for backyard rearing in Karnataka) chicken and to assess the impact of farm rearing of native chicken on meat quality.

5.1 Carcass characteristics

In the present study, a significant difference ($P<0.05$) in live weight, carcass weight and dressing per centage was evident between backyard native chicken (BNC), farm reared native chicken (FNC) and Giriraja Chicken (GR), with higher weight being recorded in GR followed by FNC and BNC. The GR recorded higher dressing per centage of 72.8, followed by FNC (67.41 %) and BNC (65.40 %). Feeding of commercial diet was found to significantly improve live weight and dressing per centage in FNC as compared to BNC. Similar to the findings of the present study higher weight and dressing per cent has been recorded by Poltowicz and Doktor (2012) in hybrid birds, Haunshi *et al*. (2013) in Aseel and Kadaknath birds, Patel *et al*. (2014) in Gramapriya birds reared under backyard system and Devatkal *et al*. (2018) in Aseel. The present results were also in agreement with the reports of Kondaiah and Panda (1987) and Sobana *et al*. (2011).

Dressing per centage is related to the age of the bird and as age advances there is considerable reduction in dressing per centage due to shrinkage of muscle. In our study lowest dressing per cent was recorded in BNC similar to that reported by Singh and Pathak (2017) who observed that the dressing percentage of broiler strain (Cobb-400) was significantly higher than all indigenous breeds (Aseel, Kadaknath, Vanaraja) studied.

In concurrence with the findings of our study, Rajkumar *et al*. (2016), observed higher live weight and dressing per cent in commercial broilers as compared to Aseel birds. Ikusika *et al*. (2020) and Rajkumar *et al*. (2020) observed similarly lower weights in indigenous birds as compared to coloured broilers. This may be attributed to the inherent qualities of slow growth and feed conversion in indigenous birds as compared to fast-growing broiler inheritance present in Giriraja chicken.

Giriraja chicken (GR) had higher yield of breast, wings, thigh and drumstick as compared to FNC and BNC, whereas BNC recorded the highest yield of back and neck. No significant difference in yield of cut up parts could be evidenced between BNC and FNC indicating that changes in feeding practices did not have significant influence of yield of cut up parts in native chicken. Similar, findings were documented by Rajkumar *et al*. (2016) who observed higher yield of primal cuts (legs and breast) in broilers as compared to Aseel and Nielsen *et al*. (2003) who reported that slow-growing chickens were characterized by a lower breast, thigh and drumstick yield and higher back and neck yield compared to that of fast-growing chickens. Similarly, Sandercock *et al*. (2009) reported that fast-growing broilers had higher breast and thigh meat as compared with layer or local chickens.

5.2 Meat quality characteristics of Breast muscle

5.2.1 Physico-chemical characteristics

A significant difference ($P<0.05$) in pH_{45min} of breast muscle was observed between BNC and FNC, whereas no significant ($P>0.05$) difference could be observed between BNC and GR and between FNC and GR. The pH at 45 mins in breast muscles ranged from 6.39 to 6.50 and lower ultimate pH (pH_{24hrs}) was recorded in GR (5.86) as compared to BNC (6.01) and FNC (6.00). The results of the present study indicated that the birds were not under any kind of pre-slaughter stress as the pH at 45 minutes were well within the range of pH of normal rested birds of 6.5-6.8 (Lawrie, 2011). The results were in concurrence with the findings of Devatkal *et al*. (2018). Lower ultimate pH in GR in the present study could be attributed to higher glycogen reserves in GR as compared to BNC and FNC resulting in increased lactic acid production and drop in pH. Similar findings have been recorded by Ilavarasan *et al*. (2016) in breast muscle of Aseel, Lakshani *et al.* (2016) in Aseel birds, Kumar *et al*. (2012) in breast meat of chicken, Wattanachant *et al*. (2004) in breast meat of indigenous chicken.

Water holding capacity is the ability of meat to retain moisture during various stages of processing and is directly related to the juiciness of the product. In the present study, a significant difference (P<0.05) in WHC of breast muscle between BNC and GR and between FNC and GR was observed. Breast muscle of BNC had higher WHC followed by FNC and GR. The lower WHC in GR may be attributed to lower ultimate pH as compared to BNC and FNC, as WHC is least at ultimate pH (5.4-5.6) and increases on either side (Hendrick *et al*., 1994). The results of the present study are in accordance with the findings of Reddy *et al.* (2016) who observed higher WHC in spent breeder hen compared to broilers. However, contrary to the findings of our study Fanatico *et al.* (2007) found that chicken raised under free range production system had significantly lower water holding capacity and Wang *et al*. (2009) reported lower WHC in slow growing chicken.

A significant difference (P<0.05) in drip and cooking loss of breast muscle between BNC and GR and between FNC and GR was observed, with GR recording highest drip loss and cooking loss. The higher drip and cooking loss may be attributed to lower ultimate pH which resulted in lower WHC in breast muscle from GR as compared to native chicken. Similar findings were recorded by Baeza *et al*. (2002) who observed a decrease in drip loss with increasing age at slaughter in duck breast muscle. However, Khan *et al*. (2019) and Devatkal *et al*. (2018) did not observe any difference in drip loss and cooking loss between native chicken and commercial broilers.

The colour of the meat provides the consumer the first impression on the quality of meat. The fresh meat acceptability by consumers is directly related to an appealing meat color and which in turn depends on myoglobin content, chemical state of heme structure and meat pH (Fletcher, 2002). Colour values of fresh meat was found to be significantly (P<0.05) different among the three groups in our study. Breast muscle of GR had higher L* (lightness) value and lower a* and b* values compared to BNC and FNC which had higher a* and b* values. The higher redness scores in breast muscle of BNC and FNC could be due to high myoglobin content and generally, broiler breast muscles with lower a* values have lower total pigment, myoglobin, and iron concentrations.

Similarly, higher redness scores have been documented by Rajkumar *et al*. (2016) in Aseel breast meat compared to commercial broilers of Cobb 400 strain and Jaturasitha *et al*. (2008) in Bresse chicken as compared to Rhode Island Red (a layer-type breed), which showed paler (higher L*) and more yellow (high b*) meat. Both the researchers opined that the differences in meat color might be due to the strong influence of genotypes of birds.

5.2.2 Structural characteristics

Muscle fibre diameter (MFD) is a function which is related to muscle texture as well as tenderness. In the present study a significant difference (P<0.05) in MFD was observed between all three groups. BNC had higher MFD (58.52 µm) values compared to

FNC (50.30 µm) and GR (42.88 µm). The results of MFD in this study were in agreement with Devatkal *et al*. (2018) in breast muscle of broiler and Aseel and Muthulakshmi *et al*. (2016) in spent layer breast muscle. However, Ilavarasan *et al*. (2016) recorded higher MFD values (75 µm and 94 µm) in breast muscles of 8 weeks and 40 weeks old Aseel birds. The differences in MFD reported in various studies might be due to breed and age effects.

A significant difference (P<0.05) in sarcomere length (SL) was evident between BNC and GR, whereas no significant difference was observed between BNC and FNC and between FNC and GR. Sarcomere length was higher in GR (1.51 µm) followed by FNC (1.42 µm) and BNC (1.29 µm). The results were in concurrence with Cavitt *et al*. (2004) who reported that sarcomere length of broiler chicken ranged from 1.57 µm to 1.71 µm and Choe and Kim (2020) who observed that the sarcomere length of different chicken genotypes ranged from 1.36 to 1.60 µm.

A significant difference (P<0.05) was observed in collagen content among all three groups, with higher collagen content reported in BNC (489.1) followed by FNC (403.2) and GR (361.3). Similar observation of higher collagen content in breast meat of native chicken compared to broilers have been reported by Wattanachant *et al*. (2004), Chen *et al.* (2016) in Chinese crossbred chicken, Reddy *et al*. (2016) and Muthulakshmi *et al*. (2016) in spent layers.

The Mean ± SE of shear-force (kg/cm^2) revealed a significant difference (P<0.05) between BNC and FNC and between BNC and GR, whereas no significant (P>0.05) difference was evident between FNC and GR. BNC had higher Shear force value (5.89) followed by FNC (5.01) and the lowest value being recorded in GR (4.84). The lowest shear force value in the present study could be attributed to higher collagen content and lower sarcomere length in BNC and FNC as compared to GR. It has been reported that shear force value and sarcomere length had negative correlation in duck and chicken breast meat and that sarcomere shortening was a major contributor to the toughness of meat and higher sarcomere length resulted in lower shear force values (Dunn *et al*., 2000). The higher shear force values in native birds might also be due to lower collagen solubility as heat stable crosslink in collagen increases with the age of the birds (Singh and Pathak, 2017).

5.2.3 Proximate composition

The results of the present study revealed a significant difference ($P<0.05$) in proximate composition among the three groups of birds. Higher moisture was observed in BNC followed by FNC and GR, whereas GR had higher protein content followed by FNC and BNC. Fat and ash content of BNC was the lowest wherein highest fat was observed in GR. Similar observations has been documented by Wattanachant *et al.* (2004) who opined that indigenous chicken muscles contained lower fat and ash content than those of broiler muscles. Valavan *et al*. (2016) and Liu and Niu (2008) also reported highest quantity of protein and crude fibre in broiler breast meat as compared to native chicken and that crude fat content of native chicken was significantly lower than the commercial broiler. However, Jaturasitha *et al*. (2008) and Haunshi *et al*. (2013) reported that moisture and protein contents of the breast muscle did not significantly differ among different genotype in chicken.

A significantly higher (P<0.05) cholesterol (mg/100g) was observed in breast muscle of GR (78.57) compared to BNC (35.83) and FNC (36.17). Similar finding has been documented by Ali *et al*. (2018) in commercial strains of native chicken. The Cholesterol content in broiler chicken muscle ranged from 30– 180 mg/100 g (Anitha *et al*., 2007). The lower cholesterol content in BNC may be attributed to higher metabolic activity under free range condition and in FNC might be due to genetic influences (Rajkumar *et al.,* 2017). The cholesterol content of GR in this study was lower than that reported by Salma *et al*. (2007) (93.6 ± 9.4 mg/100 g) in the breast muscle of broilers.

5.2.4 Sensory characteristics

Sensory characteristics and functional properties of poultry meat are critical not only for consumer's initial selection but also for final product satisfaction and the most important quality attributes are appearance and texture. Major appearance quality issues are skin and meat colour while meat tenderness, juiciness and flavour are primarily associated with texture traits. In the present study, no significant difference in appearance and flavour was observed among all the three group of birds, whereas a significant difference (P<0.05) was observed in juiciness, tenderness and overall acceptability of breast muscle. GR recorded higher juiciness, tenderness and overall acceptability as compared to BNC and FNC which did not have any significant difference. Khan *et al*. (2019) observed that breast meat of Aseel chicken received lower flavour, tenderness and juiciness scores than those of broiler and broiler breeder. They opined that higher juiciness might be attributed increased fat levels in the meat and intramuscular fat. However, contrary to our findings an appreciably higher sensory score for Aseel meat was reported by Rajkumar *et al*. (2016), Wattanachant *et al*. (2004) and Jayasena *et al*. (2013) as compared to commercial broilers.

5.3 Meat quality characteristics of Thigh muscle

5.3.1 Physico-chemical characteristics

A significant difference (P<0.05) in pH_{45min} and pH_{24h} of thigh muscle was observed between FNC and GR and between BNC and GR. Lower ultimate pH was evident in thigh muscle of GR. These pH differences are probably due to the differences in muscle type and glycogen content, which change according to the proportion of the muscle fibers that are responsible for different patterns of muscle metabolism. These results are also in agreement with Wattanachant *et al*. (2004), Berri *et al*. (2005), and Santos *et al*. (2005). The rate of pH decline is dependent on the activity of glycolytic enzymes just after death and the ultimate pH is determined by the initial glycogen reserves of the muscle. Contrary to our findings Fanatico *et al*. (2007) reported lower ultimate meat pH for slow-growing genotypes compared to the fast-growing counterpart.

No significant difference was observed between BNC and FNC and between FNC and GR, whereas a significant difference (P<0.05) in drip loss was evident between BNC and GR. Statistically, there was a significant difference (P<0.05) in cooking loss of thigh meat between BNC and GR and between FNC and GR. Drip loss and cooking loss were higher in GR as compared to BNC and FNC. This might be due to lower WHC and lower ultimate pH in GR compared to native birds.

A significant difference (P<0.05) in L*, a* and b* values of thigh muscle was observed between BNC and GR and between FNC and GR. However, no significant (P>0.05) difference could be observed between BNC and FNC in all the colour values. Thigh muscle from GR had the higher L* and b* values, whereas the thigh muscle of BNC and FNC had higher a* values compared to the other groups. In line with the results of our study, Jung *et al*. (2011) observed that thigh muscle of Korean native chicken had higher a*values compared to commercial broilers. Higher redness (a*) value of thigh muscle have been documented in Aseel birds by Devatkal *et al*. (2018), Khan *et al*. (2019) and Rajkumar *et al*. (2020).

5.3.2 Structural characteristics

The Mean ± SE of the muscle fibre diameter of BNC, FNC and GR thigh muscle revealed that BNC had higher MFD (59.64 µm) as compared to FNC (54.57 µm) and GR (50.49 µm). However, a reverse trend was observed with respect to sarcomere length which was highest in GR (1.79 µm) flowed by FNC (1.54 µm) and BNC (1.44 µm). In concurrence with our results, Yi Ping *et al*. (2016) observed that the diameter of muscle fibre increased with increase in the age of the birds, and hence BNC had higher diameter as compared to other two groups as there was difference in the age at slaughter in the present study. The muscle fibre diameter reported by Reddy *et al*. (2017) in 20-week-old Rajasri chicken were in agreement with the values recorded in BNC and FNC in our study.

A significant difference (P<0.05) in collagen content was observed in collagen content between BNC and GR, whereas no significant (P>0.05) difference was evident in collagen content between BNC and FNC and between FNC and GR. Collagen content was higher in thigh muscle from BNC (503.6) and the lowest was recorded in GR (378.6). The results are in agreement with Intarapichet *et al*. (2008) who observed higher collagen content in thigh muscle of 5-lines cross of Thai hybrid native chicken as compared to commercial broiler at 8 weeks of age.

Statistical analysis revealed a significant difference (P<0.05) in SFV of thigh muscle with BNC having higher shear value followed by FNC and GR. Similar findings were reported by Tang *et al*. (2009) who found that thigh muscle of the older slow-growing birds (110 days age) had higher SFV than the fast-growing birds (49 and 56 days). This could be explained by the differences in collagen content, cross-linking in collagen and sarcomere length with increase in age of indigenous birds.

5.3.3 Proximate composition

A significant difference (P<0.05) in moisture, protein, fat, ash and cholesterol content of thigh muscle was observed between BNC, GR and FNC. Thigh muscle from GR recorded highest protein, fat, ash, carbohydrates, cholesterol and energy as compared to BNC and FNC. The moisture content of thigh muscle from BNC was highest compared to other groups. Similar values have been documented in thigh muscles of indigenous chicken by Chueachuaychoo *et al*. (2011), Marapana (2016) and Rajkumar *et al*. (2020). Nowsad *et al*. (2000) reported higher moisture and less protein in the meat of spent hens compared to that of broilers. Similar to the present study, Jaturasitha *et al*. (2008) also found a lower fat content in thigh meat of indigenous strains of birds and higher fat in Bresse and Rhode chickens, respectively.

5.3.4 Sensory characteristics

Results of sensory analysis revealed a significant difference (P<0.05) in appearance, flavour, juiciness, tenderness and overall acceptability of thigh muscles from BNC, FNC and GR. Except for flavour scores GR had better scores for all other sensory characteristics compared to BNC and FNC. Similar findings were documented by Khan *et al*. (2019) who observed that Aseel scored lower for colour and acceptability than broiler breeders and broilers. The sensory results obtained are consistent with the findings of Huang *et al*. (2007) and Jayasena *et al*. (2013) who reported unique flavour of native chickens. However, another study conducted by Rajkumar *et al*. (2016) reported non-significant variation among different chicken genotypes regarding appearance and flavour. The obtained juiciness and tenderness results are in agreement with Amorim *et al*. (2016), who reported that broilers scored higher scores compared with roosters.

5.4 Comparison of Breast and Thigh muscle

Irrespective of the three group of birds in the present study (BNC, FNC and GR) comparison of thigh and breast meat revealed that thigh meat had significantly higher ultimate pH, water holding capacity, lightness as compared to breast muscles. In line with our findings, Souza *et al*. (2011), Sampaio *et al*. (2012) and Reddy *et al* (2017) observed that ultimate pH of thigh muscle was higher compared to breast muscle.

Thigh muscles from BNC, FNC and GR had higher redness (a*) value, higher fat, higher cholesterol and lower protein content as compared to breast muscle. Higher shear force, collagen content, muscle fibre diameter and sarcomere length were evident in thigh muscle than breast muscle. Similarly, Choe and Kim (2020) observed significantly longer sarcomere, higher collagen content and increased shear values in thigh meat than in breast meat. Lin *et al*. (2014) evaluated the meat quality characteristics of Taiwan game hens and observed a lowest fat content in breast compared to thigh meat, and that total collagen contents in thigh meat of the free-range group were significantly higher than those of the cage. Similarly, Chen *et al.* (2016) observed that soluble collagen, total collagen and collagen solubility of thigh meat were higher than that in breast meat regardless of chicken breeds.

Sensory analysis revealed that except for flavor scores no significant difference could be observed between breast and thigh muscles, wherein thigh muscle had higher flavor scores. However, Giriraja chicken meat received better sensory scores as compared to BNC and FNC. The results were in agreement with Dyubele *et al*. (2010) who observed that broiler chicken meat received higher consumer sensory scores than meat from indigenous chickens. Similar to our findings Khan *et al*. (2019) compared the sensory attributes of thigh and breast meat from broilers, broiler breeder and Aseel and opined that the sensory panelists did not find any difference in aroma, taste, flavor, juiciness and tenderness among three genotypes.

Summary

VI. SUMMARY

The present study has been undertaken at Department of Livestock Products Technology, Veterinary College, Hebbal, Bangalore in collaboration with Department of Poultry Science to compare the carcass and meat quality characteristics of backyard native, farm reared native and Giriraja (dual purpose meat breed propagated for backyard rearing in Karnataka) chicken and to assess the impact of farm rearing of native chicken on meat quality characteristics.

Evaluation of carcass characteristics revealed a significant difference ($P<0.05$) in live weight, carcass weight and dressing per centage between backyard native chicken (BNC), farm reared native chicken (FNC) and Giriraja Chicken (GR), with higher weight being recorded in GR followed by FNC and BNC. The GR recorded higher dressing per centage of 72.8, followed by FNC (67.41 %) and BNC (65.40 %). Data on yield of cut up parts revealed a significant difference ($P<0.05$) in yield of different cut up parts between BNC, FNC and GR. Among the groups GR recorded the highest yield of breast, thigh, wings and drumstick compared to other groups. A significantly ($P<0.05$) higher yield of neck and back was observed in BNC followed by FNC. However, no significant ($P>0.05$) difference could be observed between BNC and FNC in yield of all the cut-up parts.

Comparison of meat quality characteristics *viz.*, physico-chemical, structural, compositional and sensory attributes of breast muscle from BNC, FNC and GR:

A significant difference ($P<0.05$) in pH_{45min} of breast muscle between BNC and FNC was observed, whereas no significant ($P>0.05$) difference could be observed between BNC and GR and between FNC and GR. The pH at 45 mins in breast muscles ranged from

6.39 to 6.50 and lower ultimate pH (pH_{24hrs}) was recorded in GR (5.86) as compared to BNC (6.01) and FNC (6.00). In the present study, a significant difference (P<0.05) in WHC of breast muscle between BNC and GR and between FNC and GR was observed. Breast muscle of BNC had higher WHC followed by FNC and GR. A significant difference (P<0.05) in drip and cooking loss of breast muscle between BNC and GR and between FNC and GR was observed, with GR recording highest drip loss and cooking loss. Colour values of fresh meat were found to be significantly (P<0.05) different among the three groups in our study. Breast muscle of GR had higher L* (lightness) value and lower a* and b* value compared to BNC and FNC which had higher a* and b* values.

A significant difference (P<0.05) in muscle fibre diameter and collagen content was observed amomg all three groups. BNC had higher MFD (58.52 µm) values compared to FNC (50.30 µm) and GR (42.88 µm). Higher collagen content (mg/100g) was reported in BNC (489.1) followed by FNC (403.2) and GR (361.3). A significant difference (P<0.05) in sarcomere length (SL) was evident between BNC and GR, whereas no significant difference was observed between BNC and FNC and between FNC and GR. Sarcomere length was higher in GR (1.51 µm) followed by FNC (1.42 µm) and BNC (1.29 µm). The Mean ± SE of shear-force (kg/cm^2) revealed a significant difference (P<0.05) between BNC and FNC and between BNC and GR, whereas no significant (P>0.05) difference was evident between FNC and GR. BNC had higher Shear force value (5.89) followed by FNC (5.01) and the lowest value being recorded in GR (4.84).

The results of the present study revealed a significant difference (P<0.05) in proximate composition amomg the three groups of birds. Higher moisture was observed in

BNC followed by FNC and GR, whereas GR had higher protein content followed by FNC and BNC. Fat and ash content of BNC was the lowest and highest fat was observed in GR. A significantly higher ($P<0.05$) cholesterol (mg/100g) was observed in breast muscle of GR (78.57) compared to BNC (35.83) and FNC (36.17). In the present study, no significant difference in appearance and flavour was observed amomg all the three group of birds, whereas a significant difference ($P<0.05$) was observed in juiciness, tenderness and overall acceptability of breast muscle. GR recorded higher juiciness, tenderness and overall acceptability as compared to BNC and FNC which did not have any significant difference.

Comparison of meat quality characteristics viz., physico-chemical, structural, compositional and sensory attributes of thigh muscle from BNC, FNC and GR

A significant difference ($P<0.05$) in pH_{45min} and pH_{24h} of thigh muscle was observed between FNC and GR and between BNC and GR. Lower ultimate pH was evident in thigh muscle of GR. No significant difference was observed between BNC and FNC and between FNC and GR, whereas a significant difference ($P<0.05$) in drip loss was evident between BNC and GR. Statistically, there was a significant difference ($P<0.05$) in cooking loss of thigh meat between BNC and GR and between FNC and GR. Drip loss and cooking loss were higher in thigh muscle from GR as compared to BNC and FNC.

A significant difference ($P<0.05$) in L*, a* and b* values of thigh muscle was observed between BNC and GR and between FNC and GR. However, no significant ($P>0.05$) difference could be observed between BNC and FNC in all the colour values. Thigh muscle from GR had the higher L* and b* values, whereas the thigh muscle of BNC and FNC had higher a* values compared to the other groups. The Mean ± SE of the muscle fibre diameter of BNC, FNC and GR thigh muscle revealed that BNC had higher MFD (59.64 µm) as compared to FNC (54.57 µm) and GR (50.49 µm). However, a reverse trend was observed with respect to sarcomere length which was highest in GR (1.79 µm) followed by FNC (1.54 µm) and BNC (1.44 µm).

A significant difference (P<0.05) in collagen content was observed in collagen content between BNC and GR, whereas no significant (P>0.05) difference was evident in collagen content between BNC and FNC and between FNC and GR. Collagen content was higher in thigh muscle from BNC (503.6) and the lowest was recorded in GR (378.6). Statistical analysis revealed a significant difference (P<0.05) in SFV of thigh muscle with BNC having higher shear value followed by FNC and GR. Similar findings

A significant difference (P<0.05) in moisture, protein, fat, ash and cholesterol content of thigh muscle was observed between BNC, GR and FNC. Thigh muscle from GR recorded highest protein, fat, ash, carbohydrates, cholesterol and energy as compared to BNC and FNC. The moisture content of thigh muscle from BNC was highest compared to other groups. Results of sensory analysis revealed a significant difference (P<0.05) in appearance, flavour, juiciness, tenderness and overall acceptability of thigh muscles from BNC, FNC and GR. Except for flavour scores GR had better scores for all other sensory characteristics compared to BNC and FNC.

Based on the results of our present study it may be concluded that:

1. The carcass characteristics of Giriraja birds were found to be superior in terms of higher dressing percentage and yield of major cut up parts such as breast, thigh and drumstick as compared to backyard and farm native chicken.

2. Meat quality characteristics of breast and thigh muscle from BNC, FNC and GR revealed no significant differences between BNC and FNC indicating that commercial rearing of native chicken to attain better feed efficiency did not alter majority of the meat quality characteristics. However, compared to Giriraja, native chicken (BNC and FNC) had better proximate profiles (low fat, high protein and low cholesterol).

3. No significant difference could be observed in terms of sensory scores of breast and thigh muscle amomg Giriraja, BNC and FNC. The panelist preferred GR breast and thigh muscle as compared to BNC and FNC which was little tougher and less juicer. Comparing the sensory scores of thigh and breast muscle the panelists scored thigh meat higher as compared to breast meat irrespective of the genotype.

4. Thigh muscle being the most preferred cut in India, irrespective of the genotype (BNC, FNC and GR) had higher fat, cholesterol, collagen content and was much tougher compared to breast muscle.

5. The consumer perception of the unique flavor of meat from indigenous birds, for which the premium price is being paid, could not be scientifically justified in this study. However, further in-depth studies on isolation of compounds scientifically proven to have effect on the flavor of meat might throw light on the claimed unique flavor of backyard native chicken.

Bibliography

VII. BIBLIOGRAPHY

ABDULLAH, A.Y. and MATARNEH, S.K., 2010. Broiler performance and the effects of carcass weight, broiler sex, and post chill carcass aging duration on breast fillet quality characteristics. *Journal of Applied Poultry Research,* 19(1): 46-58.

ALI, M., LEE, S.Y., PARK, J.Y., JUNG, S. JO, C. and NAM, K.C., 2018. Comparison of Functional Compounds and Micronutrients of Chicken Breast Meat by Breeds. *Food Sci. Anim. Resour.,* **39**(4): 632-642.

AMORIM, A., RODRIGUES, S., PEREIRA, E. and TEIXEIRA, A., 2016. Physicochemical composition and sensory quality evaluation of capon and rooster meat. *Poultry Sci.,* **95**: 1211–1219.

ANITHA, B., MOORTHY, M. and VISWANATHAN, K., 2007. Muscle cholesterol and serum biochemical changes in broilers fed with crude rice bran oil. *Int. J Poult. Sci.,* **6**: 855–857.

AOAC (Association of Official Analytical Chemists) 2005. Official Method of Analysis (18th Ed.). Virginia, USA, 20-22.

BABIKER, S.A., EL KHIDER, I.A. and SHAFIE, S.A., 1990. Chemical composition and quality attributes of goat meat and lamb. *Meat Sci.,* **28**(4): 273-277.

BAEZA, E., DESSAY, C., WACRENIER, N., MARCHE, G. and LISTRAT, A., 2002. Effect of selection for improved body weight and composition on muscle and meat characteristics in Muscovy duck. *Br. Poult. Sci.,* **43**: 560–568.

BANDAY, M.T. and RISAM, K.S., 2001. Growth performance and carcass characteristics of broiler chicken fed with probiotics. *Indian J. Poult. Sci.,* **36**: 252-255.

BASIC ANIMAL HUSBANDRY AND FISHERIES STATISTICS, 2018. Animal Husbandry Statistics Division, Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, Govt. of India.

BERRI, C., DEBUT, M., SANT´E-LHOUTELLIER, V., ARNOULD, C., BOUTTEN, B., SELLIER, N., BAEZA, E., JEHL, N., JEGO, Y., DUCLOS, M.J. and LE BIHAN-DUVAL, E., 2005. Variations in chicken breast meat quality: implications of struggle and muscle glycogen content at death. *Br. Poult. Sci.,* **46**: 5.

BINDU, J., RAVISHANKAR, C.N. and GOPAL, T.S., 2007. Shelf-life evaluation of a ready-to-eat black clam (Villorita cyprinoides) product in indigenous retort pouches. *J. Food Eng.*, **78**(3): 995-1000.

BOSSELMANN, A., MOLLER, C., STEINHART, H., KIRCHGESSNER, M. and SCHWARZ, F.J., 1995. Pyridinoline cross-links in bovine muscle collagen**.** *Journal of Food Science,* **60:** 953-958.

BUZALA, M. and JANICKI, B., 2016. Review: Effects of different growth rates in broiler breeder and layer hens on some productive traits. *Poultry Sci.,* **95**(9): 2151-2159.

CAVITT, L.C., YOUM, G.W., MEULLENET, J.F., OWENS, C.M. and XIONG, R., 2004. Prediction of poultry meat tenderness using razor blade shear, Allo–Kramer shear, and sarcomere length. *J Food Sci.,* **69**: SNQ11–SNQ15.

CHATTERJEE, R. N. and RAJKUMAR, U., 2015. An overview of poultry production in India. *Indian J. Anim. Health.,* **54**: 2449–2454.

CHEN, J.L., ZHAO, G.P., ZHENG, M.Q., WEN, J. and YANG, N., 2008. Estimation of genetic parameters for contents of intra muscular fat and inosine -5 –monophosphate and carcass traits in Chinese Beijing –You chickens. *Poult Sci.,* **87**: 1098–1104.

CHEN, Y., QIAO, Y., XIAO, Y., CHEN, H., ZHAO, L., HUANG, M. and Zhou, G., 2016. Differences in Physicochemical and Nutritional Properties of Breast and Thigh Meat from Crossbred Chickens, Commercial Broilers, and Spent Hens. *Asian-Australasian Journal of Animal Sciences*, **29**(6): 855–864.

CHOE, J. and KIM, H.Y., 2020. Physicochemical characteristics of breast and thigh meats from old broiler breeder hen and old laying hen and their effects on quality properties of pressed ham. *Poultry Science*, **99**(4): 2230-2235.

CHOE, J.H., JAE-CHEONG, L. and JO, C., 2009. Relationship between the Economical Defects of Broiler Meat Carcass and Quality Grade A with a Meat Grader. *Korean Journal for Food Science of Animal Resources,* 29: 5851.

CHUEACHUAYCHOO, A., WATTANACHANT, S. and BENJAKUL, S., 2011. Quality characteristics of raw and cooked spent hen pectoralis major muscles during chilled storage: effect of salt and phosphate. *Int. Food Res. J.,* **18:** 601-613.

CHUMNGOEN, W. and TAN, F.J., 2015. Relationships between Descriptive Sensory Attributes and Physicochemical Analysis of Broiler and Taiwan Native Chicken Breast Meat. *Asian-Australas J Anim. Sci.,* **28**(7):1028-37.

DAS, H.K., MEDHI, A.K. and ISLAM, M., 2005. Effect of probiotics on certain blood parameters and carcass characteristics of broiler chicken. *Indian J. Poult. Sci.,* **40**: 83–86.

DEMARCHI, M., CASSANDRO, M., LUNARDI, E., BALDAN, G. and SIEGEL, P.B., 2005. Carcass characteristics and qualitative meat traits of the Padovana breed of chicken. *International Journal of Poultry Science,* **4**: 233-238.

DEMIREL, G., PEKEL, A.Y., ALP, M. and KOCABAGL, N., 2012. Effects of dietary supplementation of citric acid, copper, and microbial phytase on growth performance and mineral retention in broiler chickens fed a low available phosphorus diet. *J. Appl. Poult. Res.,* **21**: 335-347.

DEVATKAL, K., VISHNURAJ, M.R., KULKARNI, V.V. and KOTAIAH, T., 2018. Carcass and meat quality characterization of indigenous and improved variety of chicken genotypes. *Poult. Sci.,* **97:** 2947-2956.

DEVI, S.M., BALACHANDAR, V., LEE, S.I. and KIM, I.N., 2014. An Outline of Meat Consumption in the Indian Population - A Pilot Review. *Korean J. Food Sci. Ani.,* **34**(4): 507-515.

DRANSFIELD, E., CASEY, J.C., BOCCARD, R., TOURAILLE, C., BUCHTER, L., HOOD, D.E., JOSEPH, R.L., SCHON, I., CASTEELS, M., COSENTINO, E. and TINBERGEN, B.J., 1983. Comparison of chemical composition of meat determined at eight laboratories. *Meat Sci.,* **8**(2): 79-92.

DUNN, A.A., TOLLAND, E.L.C., KILPATRICK, D.J. and GAULT, N.F.S., 2000. Relationship between early post-mortem muscle pH and shortening-induced toughness in the Pectoralis major muscle of processed broilers air-chilled at 0°C and −12 °C. *Br. Poult. Sci.,* **41**: 53–60.

DYUBELE, N.L., MUCHENJE, V., NKUKWANA, T.T. and CHIMONYO, M., 2010. Consumer sensory characteristics of broiler and indigenous chicken meat: A South African example. *Food Qual. Prefer.,* **21**: 815–819.

ERTBJERG, P. and PUOLANNE, E., 2017. Muscle structure, sarcomere length and influences on meat quality: A review. *Meat Science,* **132**: 139– 152.

FANATICO, A.C., PILLAI, P.B., EMMERT, J.L. and OWENS, C.M., 2007. Meat quality of slow- and fast-growing chicken genotypes fed low-nutrient or standard diets and raised indoors or with outdoor access. *Poult. Sci.,* **86**: 2245–2255.

FANATICO, A.C., PILLAI, P.B., EMMERT, J.L. and OWENS, C.M., 2007. Meat quality of slow-growing chicken genotypes fed low-nutrient or standard diets and raised indoor or with outdoor access**.** *Poult. Sci.,* **86**: 2245-2255.

FLETCHER, D.L., 2002. Poultry meat quality. *Worlds Poult. Sci. J.,* **58**:131–145.

HASSANPOUR, H., TESHFAM, M., MOMTAZ, H., BRUJENI, G.N. and SHAHGHOLIAN, L., 2010. Up-regulation of endothelin-1 and endothelin type A receptor genes expression in the heart of broiler chickens versus layer chickens. *Res. Vet. Sci.,* **89**: 352-357.

HAUNSHI, S., SUNITHA, M., SHANMUGAM, R., PADHI, M.K. and NIRANJAN, M., 2013. Carcass characteristics and chemical composition of breast and thigh muscle of native chicken breeds. *Indian J. Poult. Sci.,* **48**: 219-222.

HENDRICK, H.B., ABERLE, E.B., FORREST, J.C., JUDGE, M.D. and MERKEL, R.A., 1994. Principles of Meat Science (Third eds.). Dubuque, Iowa: Kendall/Hunt Publishing Company.

HOOD, D.E., 1980. Factors affecting the rate of metmyoglobin accumulation in pre-packaged beef. *Meat Science,* **4**: 247–265.

HOSTETLER, R.L., LINK, B.A., LANDMANN, W.A. and FITZHUGH JR, H.A., 1972. Effect of carcass suspension on sarcomere length and shear force of some major bovine muscles. *J. Food Sci.*, **37**(1): 132-135.

HUANG, C.C., HSIEH, C.C. and CHIANG, S.H., 2007. Estimating the energy partitioning of Taiwanese native chickens by mathematical model. *Animal Feed Science and Technology,* **134**: 189–197.

IKUSIKA, O.O., FALOWO, A.B., MPENDULO, C.T., ZINDOVE, T.J. and OKOH, A.I., 2020. Effect of strain, sex and slaughter weight on growth performance, carcass yield and quality of broiler meat. *Open Agriculture,* **5**: 607-616.

ILAVARASAN, R., ABRAHAM, R.J.J. and APPA RAO, V., 2016. The relationship between meat quality characteristics and nutritional composition of Nandanam quail-iii slaughtered at different ages. *J. Anim. Res.,* **6**: 95-100.

INTARAPICHET, K.O., SUKSOMBAT, W. and MAIKHUNTHOD, B., 2008. Chemical Compositions, Fatty Acid, Collagen and Cholesterol Contents of Thai Hybrid Native and Broiler Chicken Meats. *Journal of Poultry Science,* 45: 7-14.

JATURASITHA, S., KAYAN, A. and WICKE, M., 2008. Carcass and meat characteristics of male chickens between Thai indigenous compared with improved layer breeds and their crossbred. *Arch Tierzucht.,* **51**: 283–294.

JAYASENA, D.D., JUNG, S., KIM, H.J., BAE, Y.S., YONG, H.I., LEE, J.H., KIM, J.G. and JO, C., 2013. Comparison of quality traits of meat from Korean native chickens and broilers used in two different traditional Korean cuisines. *Asian Australas. J. Anim. Sci.,* **26**:1038–1046.

JEON, H.J., CHOE, J.H., JUNG, Y., KRUK, Z.A., LIM, D.G. and JO, C., 2010. Comparison of the chemical composition, textural characteristics, and sensory properties of North and South Korean native chickens and commercial broilers. *Korean J. Food Sci. Ani.,* **30**: 171–178.

JEREMIAH, L.E. and MARTIN, A.H. 1978. Intramuscular collagen content and solubility: Their relationship to tenderness and alteration by post-mortem aging. *Can. J. Anim. Sci*., **61:** 53.

JEREMIAH, L.E. and MARTIN, A.H., 1977. The influence of sex, within breed-of-sire groups, upon the histological properties of bovine longissimus dorsi muscle during postmortem aging. *Can. J. Anim. Sci.,* **57**(1): 7-14.

JUNG, Y., JEON, H.J., JUNG, S., CHOE, J.H., LEE, J.H., HEO, K.N., KANG, B.S. and JO, C., 2011. Comparison of quality traits of thigh meat from Korean native chickens and broilers. *Korean J. Food Sci. An.,* **31**: 684–692.

KADIOGLU, P., KARAKAYA, M., UNAL, K. and BABAOGLU, A.S., 2019. Technological and textural properties of spent chicken breast, drumstick and thigh meats as affected by marinating with pineapple fruit juice. *Br. Poult. Sci.*, **60:** 381-387.

KEETON, J.T., 1983. Effects of fat and NaCl/phosphate levels on the chemical and sensory properties of pork patties. *J. Food Sci.*, **48**(3): 878-881.

KHAN, U., HUSSAIN, J., MAHMUD, A., KHALIQUE, A., MEHMOOD, S., BADAR, I.H., USMAN, M., JASPAL, M.H. and AHMAD, S., 2019. Comparative Study on Carcass Traits, Meat Quality and Taste in Broiler, Broiler Breeder and Aseel Chickens. *Brazilian Journal of Poultry Science*, **21**(1): eRBCA-2019-0770.

KONDAIAH, N. and PANDA, B., 1987. Physico-chemical and functional properties of spent hen components. *Journal of Food Science and Technology – India*, 24: 267-269.

KUMAR, S., BHAT, Z.F., KUMAR, P. and SINGH, P.K., 2012. Effect of sex on carcass quality parameters of Vanaraja chicken of over 72 weeks of age. *Indian Journal Poultry Sci.*, **47**(3): 377-381.

LAKSHANI, P., JAYASENA, D.D. and JO, C., 2016. Comparison of Quality Traits of Breast Meat from Commercial Broilers and Spent Hens in Sri Lanka. *Korean J. Poult. Sci.*, **43**: 55-61.

LAWRIE, R.A., 1991. Meat Science. 5th ed Oxford: Pergamon Press; (Chapter 10).

LAWRIE, R.A., 2011. Meat Science (8th ed.), Pergamon Press, Oxford, UK.

LIMPISOPHON, K., E-TUN, S., KOEIPUDSA, C., CHAROENSUK, D. and MALILA, Y., 2019. Characterization of Breast Meat Collected from Spent Lohmann Brown Layers in Comparison to Commercial Ross Broilers. *Brazilian Journal of Poultry Science*, **21**(3): eRBCA-2018-0941.

LIN, C., KUO, H. and WAN, T., 2014. Effect of Free-range Rearing on Meat Composition, Physical Properties and Sensory Evaluation in Taiwan Game Hens. *Anim. Biosci.*, **27**(6):880-885.

LIN, C.Y., KUO, H.Y. and WAN, T.H., 2014. Effect of free-range rearing on meat composition, physical properties and sensory evaluation in Taiwan game hens. *Asian-Aust. J. Anim. Sci.,* **27**: 880–885.

LIU, F. and NIU, Z., 2008. Carcass Quality of Different Meat - Typed Chickens When Achieve a Common Physiological Body Weight. *Int. J. Poult. Sci.,* **7**: 319-322.

LIVINGSTON, D.J. and BROWN, W.D., 1981. The chemistry of myoglobin and its reactions. *Food Tech.,* **35**: 244-252.

MARAPANA, R., 2016. Effect of different dress weight categories on yield part percentage and relationship of live and dress weight of broiler carcasses slaughter at different conditions. *Journal of Food Science and Technology Nepal,* **9**: 31-38.

MIR, N. A., RAFIQ, A., KUMAR, F., SINGH, V. and SHUKLA, V., 2017. Determinants of broiler chicken meat quality and factors affecting them: a review. *Journal of food Science and Technology,* **54**(10): 2997–3009.

MUCHENJE, V., DZAMA, K., CHIMONYO, M., STRYDOM, P.E., HUGO, A. and RAATS, J.G., 2008. Sensory evaluation and its relationship to physical meat quality attributes of beef from Nguni and Bonsmara steers raised on natural pasture. *Animal,* **2**(11): 1700-1706.

MURTHY, T.R.K. and DEVADASON, P.I., 2003. Buffalo meat and meat products – An overview. In Proceedings of Fourth Asian Buffalo Congress on Buffalo for Food Security and Rural Employment (I. Singh and O.P. Dhanda, eds.) pp. 193–199, Indian Society for Buffalo Development, New Delhi, India.

MUSA, H.H., CHEN, G.H., CHENG, J.H., LI, B.C. and MEKKI, D.M., 2006. Study on carcass characteristics of chicken breeds raised under the intensive condition. *Int. J. Poult. Sci.*, **5**: 530-33.

MUTHULAKSHMI, M., MUTHUKUMAR, M., RAJKUMAR, R.S., GIRISH, P.S. and MOOVENTHAN, P., 2016. Carcass characteristics and meat quality attributes of commercial culled layer hen. *International journal of Science, Environment and Technology,* **5**(5): 3352-3361.

NAVEENA, B.M., MENDIRATTA, S.K. and ANJANEYULU, A.S.R., 2004. Tenderization of buffalo meat using plant proteases from Cucumis trigonus Roxb (Kachri) and Zingiber officinale roscoe (Ginger rhizome). *Meat Sci*., **68**(3): 363-369.

NBAGR, 2019. National Bureau of Animal Genetic Resources, Karnal, India. Browsed from URL: www.nbagr.res.in.

NEUMAN, R.E. and LOGAN, M.A., 1950. The determination of hydroxyproline. *J. Biol. Chem.*, **184**, 299-306.

NIELSEN, B.L., THOMSEN, M.G., RENSEN, P.S. and YOUNG, J.F., 2003. Feed and strain effects on the use of outdoor areas by broilers. *Br Poult Sci.*, **44**:161–169.

NOWSAD, A.A.K.M., KANOH, S. and NIWA. E., 2000. Thermal gelation characteristics of breast and thigh muscles of spent hen and broiler and their surimi. *Meat Sci.*, **54**:169–175.

OLAWUMI, S.O. and FAGBUARO, S.S., 2011. Productive Performance of Three Commercial Broiler Genotypes Reared in the Derived Savannah Zone of Nigeria. *International Journal of Agricultural Res*., **6**: 798-804.

PATEL, N., SHRIVASTAVA, A.K., RAVINDRA, K. and PRASAD, S., 2014. Carcass characteristics of gramapriya birds under farm and village management condition. *Progressive Research*, **9**(1): 82-84.

PATHAK, P.K. and NATH, B.G., 2013. Rural poultry farming with improved breed of backyard chicken. *J. World's Poult. Res.,* **3**(1): 24- 27.

POLTOWICZ, K. and DOKTOR, J., 2012. Effect of slaughter age on performance and meat quality of slow-growing broiler chickens. *Ann. Anim. Sci.,* **12**: 621-631.

PREMAVALLI, K., RAJENDRAN, R., BALASUBRAMANYAM, D. and OMPRAKASH, A.V., 2018. Comparative sensory evaluation of breast meat of different chickens. *International Journal of Chemical Studies,* **6**(1): 738-740.

RAHAYU, H., IDRUS, Z., VIDYADARAN, M., ALIMON, A. and BABJEE, S., 2008. Carcass Variables and Chemical Composition of Commercial Broiler Chickens and the Red Jungle Fowl. *Asian-Australasian Journal of Animal Sci.,* **21**: 5713.

RAJAN, S., KULKARNI, V.V. and CHANDIRASEKARAN, V., 2014. Preparation and storage stability of retort processed Chettinad chicken. *J Food Sci. Technol.,* **51:** 173–177.

RAJKUMAR, U., CHANDAN, P., PRINCE, L.L.L, MUTHUKUMAR, M., HAUNSHI, S., REDDY, B.L. and CHATTERJEE, R., 2020. Studies on growth, carcass and meat quality traits in Aseel crosses suitable for small scale intensive broiler farming, *Journal of Applied Animal Research,* **48**:1, 507-514.

RAJKUMAR, U., HAUNSHI, S., PASWAN, C., RAJU, M.V.L.N., RAMA RAO, S.V. and CHATTERJEE, R.N., 2017. Characterization of indigenous *Aseel* chicken breed for morphological, growth, production and meat composition traits from India. *Poult. Sci.,* **96**: 2120–2126.

RAJKUMAR, U., MUTHUKUMAR, M., HAUNSHI, S., NIRANJAN, M., RAJU, M., RAMA RAO, S.V. and CHATTERJEE, R.N., 2016. Comparative evaluation of carcass traits and meat quality in native Aseel chickens and commercial broilers. *Br. Poult. Sci.,* **57**: 339-347.

RAO, B.E. AND RANGANADHAM, M., 2011. A study on carcass characteristics and cut-up- parts of commercial broiler (babcock) birds. *Ind. J. Poult. Sci.,* **42**: 131-145.

REDDY, G.B., MALLIKA, E.N., REDDY, B.O., AZAD, S.A.K. and REDDY, D.M., 2016. comparison on meat quality characteristics of spent breeder, layer and broiler birds. *Int. J. Sci. Environ. Technol.,* **5**: 2590-2595.

REDDY, N.A., REDDY, K.K., KUMAR, M.S., KRISHNAIAH, N. and RAO, V.K., 2017. Studies on Effect of Sex and Age on Physico-Chemical and Organoleptic Qualities of Rajasri Chicken. *Int. J. Curr. Microbiol. App. Sci.,* **6**: 406-415.

REHFELDT, C., FIEDLER, I. and STICKLAND, N.C., 2004. Number and size of muscle fibres in relation to meat production. Pages 1–38 in Muscle Development of Livestock Animals: Physiology, Genetics and Meat Quality. M. F. W. te Pas, M. E. Everts, and H. P. Haagsman, ed. CABI Publ., Cambridge, MA.

REMIGNON, H., DESROSIERS, V. and MARCHE, G., 1996. Influence of increasing breast meat yield on muscle histology and meat quality in the chicken. *Reprod. Nutr. Dev.,* **36**: 523–530.

SALMA, U., MIAH, A.G., TAREQ, K.M.A., MAKI, T. and TSUJII, H., 2007. Effect of dietary *Rhodobacter capsulatus* on egg-yolk cholesterol and laying hen performance. *Poult. Sci.,* **86**: 714-719.

SAMPAIO, G.R., SALDANHAC, T., SOARES, R.A. and TORRES, E.A., 2012. Effect of natural antioxidant combinations on lipid oxidation in cooked chicken meat during refrigerated storage**.** *Food Chem.,* **135:**1383-1390.

SANDERCOCK, D.A., NUTE, G.R. and HOCKING, P.M., 2009. Quantifying the effects of genetic selection and genetic variation for body size, carcass composition, and meat quality in the domestic fowl (*Gallus domesticus*). *Poultry Sci.,* **88**: 923-931.

SANKA, Y.D. and MBAGA, S.H., 2014. Evaluation of Tanzanian local chicken reared under intensive and semi-intensive systems: II. Meat quality attributes. *Livestock Res. Rural Develop.*, **26**: 457-462.

SANTOS, A.L., SAKOMURA, N.K., FREITAS, E.R., Fortes, C.M.L.S., CARRILHO, E.N.V.M. and FERNANDES, J.B.K., 2005. Growth, performance, carcass yield and meat quality of three broiler chicken strains. *R. Bras. Zootec.*, **34**:1589–1598.

SINGH, D.P., SINGH, U. and GURUNG, B.S., 2001. Aseel of India. Souvenir, National Seminar on Appropriate Poultry for Adverse Environment, Organized by Acharya N G Ranga Agricultural University and Project Directorate on Poultry, Hyderabad, 11th January 2001.

SINGH, V. P. and PATHAK, V., 2017. Quality characterization of giblets of indigenous Indian chicken breeds. *Int. J. Curr. Microbiol. Appl. Sci.*, **6**:784–797.

SNEDECOR, C. W. and COCHRAN, W. G., 1989. Statistical Methods, 8th edition. Ames: Iowa State University Press, USA.

SOUZA, X.R., FARIA, P.B. and BRESSAN, M.C., 2011. Proximate composition and meat quality of broilers reared under different production system. *Braz. J. Poultry Sci.*, **13**(1): 15–20.

SURIANI, N.W., PURNOMO, H., ESTIASIH, T. and SUWETJA, I.K., 2014. Physicochemical properties, fatty acids profile and cholesterol content of indigenous manado chicken, broiler and spent hen meat. *International Journal of Chem. Tech. Res.*, **6**: 3896-3902.

TANG, H., GONG, Y.Z., WU, C.X., JIANG, J., WANG, Y. and Li, K., 2009. Variation of meat quality traits among five genotypes of chicken. *Poult. Sci.*, **10**: 2212–2218.

THOMPSON, L.D., JANKY, D.M. and WOODWARD, S.A., 1978. Tenderness and physical characteristics of broiler breast fillets harvested at various times from post-mortem electrically stimulated carcasses. *Poult. Sci.*, **66**: 1158-1167.

VALAVAN, S.E., OMPRAKASH, A., BHARATIDHASAN, A., RAMESH, V. and KUMAR, S., 2016. Comparison of nutrient composition of native chicken and commercial broiler under Indian condition. *International Journal of Applied and Pure Science and Agriculture*, **12**(2): 7-11.

VINODAKUMAR, S.N. and DESAI, B.K., 2017. Poultry farming: Suitable intervention for livelihood support and nutritional security of marginal/small farmers of N-E Karnataka. *The Asian Journal of Animal Sci.*, **12**(1): 43-48.

WANG, K.H., SHI, S.R., DOU, T.C. and SUN, H.J., 2009. Effect of a free-range raising system on growth performance, carcass yield, and meat quality of slow-growing chicken. *Poult Sci.*, **88**: 2219–2223.

WARDLAW, F. B., MACCASKILL, L. H. and ACTON, J. C., 1973. Effect of postmortem muscle changes in poultry meat loaf properties. *J. Food Sci.*, **38**:421-424.

WATTANACHANT, S., BENJAKUL, S. and LEDWARD, D., 2004. Composition, color, and texture of Thai indigenous and broiler chicken muscles. *Poult. Sci.*, **83**: 123-128.

WHEELER, T.L., SHACKELFORD, S.D., JOHNSON, L.P., MILLER, M.F., MILLER, R.K. and KOOHMARAIE, M., 1997. A comparison of Warner-Bratzler shear force assessment within and among institutions. *J. Anim. Sci.*, **75**(9): 2423-2432.

WYBENGA, D.R., PILEGGI, V.J., DIRSTINE, P.H. and GIORGIO, J.D., 1970. Direct manual determination of serum total cholesterol with a single stable reagent. *Clinical chemistry*, **16**(12): 980-984.

YI-PING, L., DAN, L., YAO-DONG, H., CHAO-Wu, Y. and XIAO-Song, J. 2016. Analysis of the Chinese Indigenous Chicken's Meat Quality in Different day for Optimum Slaughter Time. *Poult. Fish Wildl. Sci.*, **4**: 162.

ZHANG, W., XIAO, S., SAMARAWEERA, H., JOO, E. and AHN, D.U., 2010. Improving functional value of meat products. *Meat Sci.*, **86**: 15–31.

ZHAO, G.P., CHEN, J.L., ZHENG, M.Q., WEN, J. and ZHANG, Y., 2007. Correlated responses to selection for increased intramuscular fat in a Chinese quality chicken line. *Poult Sci.*, **86**:2309–2314.

ZHAO, G.P., CUI, H.X., LIU, R.R., ZHENG, M.Q., CHEN, J.L. and WEN, J., 2011. Comparison of breast muscle meat quality in 2 broiler breeds. *Poultry Science,* **90**(10): 2355-2359.

ZHENG, Q., ZHANG, Y., CHEN, Y., YANG, N., WANG, X.J. and ZHU, D., 2009. Systematic identification of genes involved in divergent skeletal muscle growth rates of broiler and layer chickens. *BMC Genomics,* **10**: 87.

Abstract

VIII. ABSTRACT

The present study was carried out to compare the carcass and meat quality characteristics of backyard native (BNC), farm reared native (FNC) and Giriraja (GR) chicken. A significantly higher ($P<0.05$) live weight, carcass weight, dressing percentage and yield of breast, thigh, drumstick and wings were observed in GR. Meat quality analysis of breast muscle revealed a significantly lower ultimate pH, higher WHC, higher redness value (a*), lower cooking and drip loss in BNC. BNC breast muscle had higher MFD, collagen content, shear force value and lower sarcomere length as compared to GR. Higher moisture was observed in BNC, whereas GR breast muscle had higher protein, fat, cholesterol and ash content. Sensory analysis of breast muscle revealed that GR recorded higher juiciness, tenderness and overall acceptability. Meat quality analysis of thigh muscle from BNC, FNC and GR revealed lower ultimate pH, higher drip and cooking losses, higher L* and b* values, lower WHC, lower MFD and higher sarcomere length in GR. Collagen content and shear force values were higher in thigh muscle from BNC. Thigh muscle from GR recorded highest protein, fat, ash, carbohydrates, cholesterol and energy as compared to BNC and FNC. The moisture content of thigh muscle from BNC was highest compared to other groups. Results of sensory analysis revealed a significantly higher ($P<0.05$) appearance, flavour, juiciness, tenderness and overall acceptability scores of thigh muscles from Giriraja compared to backyard native and farm reared native chicken. Commercial rearing of native chicken did not alter meat quality and sensory characteristics in comparison with backyard native chicken. Thigh muscle was the most preferred among all the three groups by sensory panellist in spite of higher fat, cholesterol and higher collagen content. Giriraja chicken had better carcass characteristics and its meat (thigh/breast) was organoleptically more acceptable compared to native chicken.

Appendix

IX. APPENDIX

Performa for Sensory Evaluation (Keeton, 1983)

Department of Livestock Products Technology

Veterinary College, Hebbal, Bangalore

Panelist's Name: **Product's name:** **Date:**

Sensory Attributes	**Hedonic Scales for Descriptive attributes of products**							
	8	**7**	**6**	**5**	**4**	**3**	**2**	**1**
Appearance	Excellent	Very Good	Good	Fair	Slightly Poor	Moderately Poor	Very Poor	Extremely Poor
Flavor	Extremely Desirable	Very Desirable	Moderately Desirable	Slightly Desirable	Slightly Undesirable	Moderately Undesirable	Very Undesirable	Extremely Undesirable
Tenderness	Extremely Desirable	Very Desirable	Moderately Desirable	Slightly Desirable	Slightly Undesirable	Moderately Undesirable	Very Undesirable	Extremely Undesirable
Juiciness	Extremely Juicy	Very Juicy	Moderately Juicy	Slightly Juicy	Slightly Dry	Moderately Dry	Very Dry	Extremely Dry
Overall acceptability	Extremely Palatable	Very Palatable	Moderately Palatable	Slightly Palatable	Slightly Unpalatable	Moderately Unpalatable	Very Unpalatable	Extremely Unpalatable

Product code	**Appearance**	**Flavor**	**Texture/ Tenderness**	**Juiciness**	**Overall acceptability**

Remarks: **Signature**