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Carcass Characteristics of Broiler Birds as Affected by Sex and Genotype

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Abstract: The objective of this study is to determine the effect of sex and genotype on carcass characteristics of broiler chickens. A total bird of 150 day-old chick of three commercial broiler strains comprising of 50 chicks per strain (Marshall, Arbor Acre and Cobb) were used. Each strain was identified with wing tag and was kept in separate pen in an environmentally controlled brooder house. A total number of 20 males and 30 females per strain was further separated and kept in separate pen. Carcass weights such as wing, drumstick, thigh, shank, neck, head, breast and back while internal organs like proventriculus, heart, gizzard, liver, spleen, kidney, intestinal offal, abdominal fat, crop and lungs were recorded. Overall, genotype has significant effect ($p<0.05$) on all carcass and internal organs traits except abdominal fat. Arbor Acre recorded the highest weights in shank, thigh, breast, back heart, liver, spleen, intestinal offal, crop and lungs, while Cobb recorded highest weights in wings, drumstick, head, proventriculus and kidney while Marshall recorded the highest weight in neck and gizzard. Also, sex significantly ($p<0.05$) affected the carcass and internal organs traits, males recorded heavier weight in shank, thigh, breast, back, neck, heart, gizzard, liver, kidney, abdominal fat, crop, lungs while female were heavier in wings, drumstick, head, proventriculus, spleen and intestinal offal. Genotype x sex significantly ($p<0.05$) influenced all carcass and internal organs traits. The overall results of this study have shown that genotypes differed significantly in carcass and internal organs traits, with Arbor Acre having highest weight values in all carcass and internal organs traits except wings, drumstick, head, neck, proventriculus, kidney and gizzard. Also, males recorded the heaviest weights in all carcass and internal organs trait except wings, drumstick, head, proventriculus, spleen and intestinal offal. Arbor Acre male is therefore recommended for profitable broiler production because it recorded the highest carcass and internal organ traits yield.
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1.0 Introduction of the Study

Poultry production in the tropics possesses the quickest potential for bridging the protein supply – demand gap. It is an important means of rapidly increasing the availability of animal protein in the developing countries where malnutrition is a great problem (Anyawu & Okoro, 2006; Ojedapo & Adewuyi, 2022). Poultry product is considered to be one of the most popular options in Nigeria in reducing the incidence of malnutrition particularly protein deficiency in the diets of populace (Obasoyo *et al.*, 2005). The necessity of protein in man and animals diet cannot be overemphasized; the reason is that, protein plays a vital role in tissue synthesis and building of body structures. The main goal of broiler rearing is production of quality broiler carcass that will be acceptable from the consumers. Acceptability depends on the quality and quantity of edible parts of carcasses and the amount of muscle in carcass. Broiler carcass are evaluated mainly through edible parts of which are expressed by dressing percentages (slaughter yield) and quality of edible parts of carcass. All quality characteristics of carcass are inherent in the genotype and therefore conditionally hereditary characteristics with precisely defined heritability proposed values (Chen *et al.*, 1987). The marketing of poultry has been greatly diversified with a significant increase in cut - up (parts) and processed products (Le Bihan Duval *et al.*, 2001). Broiler producers generally select broiler strains and sex that reach market body weight early with good carcass characteristics in order to maximize their profit margins (Shim *et al*., 2012). In many least developed countries, there are many small scale farmers that lacks information on appropriate strain sex combinations to maximize profit. The aim of the study is to determine the interaction between genotype and sex on carcass characteristics of broiler chickens.

2.0 Literature Review of the Study

2.1 An Overview of Poultry Production

Poultry is by far the largest group of livestock and estimated to be about 14,000 million, consisting mainly of chickens, ducks and turkey in the world (FAO, 1999). Poultry in Nigeria has undergone tremendous changes over the past decades in genotypes, management and technological advancement. Large poultry unit has replaced the backyard poultry units with more strains of meat or egg type birds, feed, intensive housing and better poultry equipment (Shehu et al., 2022; Ukonu et al., 2022a). Poultry production is an aspect of livestock farming important to the biological needs, economic and social development of the people of any nation (Oladeebo & Ambe-Lamidi, 2007). In line with the increasing demand for poultry products, there has been a number of important scientific and technological developments which have resulted in the improvements of poultry production. These include the artificial incubator, effective brooding system, increased understanding of nutritional requirements and formulations of balance diets (Shehu et al., 2022; Ukonu et al., 2022a). Better management and control of diseases, improved hygiene disinfectants, vaccination and antibiotics, environmental and photoperiod manipulation through housing design and the availability of electrical power and accurate control systems are also important factors which have elicited improved production outcomes.

2.2 Broiler Production System

2.2.1 Origin of Broilers

The domestic chicken originated from the red jungle fowl (Gallus gallus Linnaeus, 1758), native to tropical South \ South East Asia. Contemporary, non-indigenous red jungle fowl occur in the Americas, Australia, Europe and Africa due to deliberate human translocation and are adapted to a much wider climatic range than indigenous birds **(**Bennet *et al.*, 2018). Before the development of modern commercial meat breeds, broilers were mostly young male chickens culled from farm flocks. The first attempt at a meat crossbred was introduced in the 1930s and became dominant in the 1960s where a crossbred variety was produced from a male of a naturally double – breasted Cornish strain and a female of a tall, large – boned strain of white Plymouth rocks. The original crossbred was plagued by problems of low fertility, slow growth and disease susceptibility (Damerow, 1995).

2.2.2 Broiler Industry

Standard intensively farmed broiler chickens are reared to their slaughtered weight (typically around 2kg, sometimes 3kg) very rapidly (Owhe-Ureghe et al., 2022). They reach slaughter weight of 2kg within about 40 days of being hatched, whereas they would not reach adulthood until about five or six months. Broilers are thus very young animals for the whole of their rearing period. By selective breeding, the length of time broiler chicks takes to grow to 2kg has been halved in the last 30 years and between 1976 to 2007, it is likely to have been reduced by 1 day every year. The amount of feed needed to achieve this weight gain has been reduced by almost 40% since 1976. Breeding for increased breast muscle means that broilers' centre of gravity has moved forward and their breast and their breast broadened compared to their ancestors (SCAHAW, 2000). The broiler industry was characterized based on age for weight. Therefore, emphasis was placed on rapid growth and early carcass development (Emmerson, 1997). The explanation was that processor's demand for chicken products including bone in and boneless pieces, within a narrow weight range, these forces producers to raise and market birds at a fixed target weight to satisfy market demands.

2.3 Breeds of Broilers

Poultry genetics has entered a new era with the completion of a century of investigative studies in chicken genetics, sequencing of the chicken genome and application of molecular genetic information in commercial breeding programs. Today's broilers industry has its origin from in the seasonal rearing of cockerels of eggs or dual purpose breeds for meat. With increasing demand for young chickens, breeds have been selected for rapid weight gain, feed conversion and high yield of valuable cut parts (Eitan & Solier, 2002). The structure of all breeder companies is quite standard, with the pure line elite stock in relatively small populations located at the apex and large numbers of broilers at the base. The mainline pedigree populations, categorized into male and female lines undergo genetic selection to obtain incremental improvements in the major economic trait. Owhe-Ureghe et al. (2022) argued that the major economic trait is improved by intensive selection (high intensity), which is regenerated from the best families. Minor traits such as fertility, hatchability and liveability are improved by eliminating the few worst families (low intensity) (Pollock, 1999). A number of broiler breeding companies have been in existence since the late 1940s and have contributed immensely to genetic improvements in broilers over the years. These companies are mostly located in the USA (North America) and Europe (England). The three major breeding companies in the world are Aviagen (with Cobb – Vantress and Avian) and Hubbard – ISA (with Hubbard and shaver).

2.3.1 Cobb: Cobb claims to be world's oldest poultry breeding company. Founded 1916 when Robert C. Cobb Senior purchased a farm in Littleton, Massachusetts, forming Cobb's pedigree Chicks. It was then purchased by Upjohn in 1974, sold to Tyson Foods in 1994. In 1947 Cobb begins a breeding line of all white birds called White Rocks. These birds along with the Vantress male provide the foundation of today's pedigree Cobb line.

2.3.2 Arbor Acre: Arbor Acrewas originally a family farm, started by an Italian immigrant Frank Sagio who purchased a Glastonbury, Connecticut farm in 1917. His third son Henry Saglio took over the poultry while in grade eight. Henry began trying to breed a white bird, because it is difficult to pluck black pin feathers. The white Arbor Acres' birds were preferred to the higher performing dark feathered Red Cornish crosses.

2.3.3 Ross: These Chickens are products of Aviagen and have been studied to have excellent live weight gain, low cost of finished meat, large and strong legs, excellent feed conversion, white and large breast, more muscle mass, rapid growth with possibility of early slaughtering and remarkable figure for survival. The optimal time for slaughtering the breed is considered to be from age six to nine weeks, at this point the chickens will have weighed up to two kilograms.

2.3.4 Marshall: Marshall breeds of broilers are noted for their tall growth with good breast attributes. They reach marketable age within six to eight weeks, depending on the quality of management as well as target weight.

2.4 Factors Affecting Carcass Characteristics of Broiler Chickens

The main goal of broiler rearing is production of quality broiler carcass that will be acceptable from the consumers. Acceptability depends on the quality and quantity of edible parts of carcasses and the amount of muscle in carcass (Ukonu et al., 2022b; Owolabi et al., 2022). Broiler carcass are evaluated through mainly through edible parts of which are expressed by dressing percentages (slaughter yield) and quality of edible parts of carcass. All quality characteristics of carcass are inherent in the genotype and therefore conditionally hereditary characteristics with precisely defined heritability proposed values (Chen *et al*., 1987). The marketing of poultry has been greatly diversified with a significant increase in cut - up (parts) and processed products (Le Bihan Duval *et al.*, 2001). The genetic constitution of the broiler chicken as well as the non-genetic factors such as nutrition, sex and age were reported in literature to have significantly influenced carcass value of broiler birds.

2.4.1 Housing and Stocking Density

Housing in poultry management is a technique involving the allocation of a specific floor space to bird to provide a comfortable environment for satisfactory performance. Stocking density is one of component of environment that plays a critical role in determining the wellbeing of a bird (Lee & Moss, 1995). Maintaining a high stocking density is a common practice of the poultry industry because it allows for an increase in economic return per unit floor space. Bandyopadhyay *et al.* (2006) reported that income per bird often decreases primarily due to reduction in growth rate, increased proportion of downgraded carcasses and greater risk of health related problems. (Estevez, 2007) reported that assigned densities have been primarily driven by cost – benefit analysis, but economic profit may come at the cost of reduced bird performance and welfare if the densities are excessive. Other studies have shown that that stocking rate affected feed consumption. Average daily weight gain, feed conversion efficiency and breast yield (Bilgi & Hess, 1995).

2.4.2 Age of Broiler Chickens

Traditionally, broilers have been bred to grow quickly so they reach their market weight by the age of 42 to 45 days. However, there is a growing trend in the poultry broiler industry to produce heavier birds for further processing (Lesson & Summer, 2001).

2.4.3 Diet Composition of Broiler Chickens

The importance of dietary feed intake cannot be overemphasized because increasing or decreasing the dietary energy has been reported to affect feed intake in addition to promoting or undermining efficient feed utilization and growth rate (Leeson & Summer, 1991; Dozier *et al.,* 2006; Dozier *et al.,* 2007; Ghaffari *et al.,* 2007). This scenario tends to lead to malnutrition, poor performance, increased deposition of excess abdominal fat or carcass fat in broilers (Ghaffari *et al.,* 2007; Singh & Panda, 1992; Summers *et al.,* 1992) and these fats are usually considered as waste product when the birds are processed.

2.4.4 Sex of Broiler Chickens

A number of studies demonstrated that female broilers have higher breast proportions, while in males the proportions of thighs were higher (Young *et al.,* 2001). In addition, Mendes *et al.* (2004) established lower abdominal fat percentage in males than females. The authors found that sex also significantly affected carcass traits through slaughter yield, percentages of wings and thigh and meat to bone ratio from the thigh. Castellini *et al.* (2014), have reported that carcass characteristics were not greatly affected by sex.

2.4.5 Genotype of Broiler Chickens

Genotype has been studied to have significant effects on carcass characteristics such as carcass fatness, meat quality, carcass weight, breast and leg muscle weight, fats and edible giblet weight and back and drumstick weights (Olawumi & Fagbuaro, 2011; Marcu *et al.,* 2013). On the other hand, Udeh *et al.* (2015) found no difference in the yield of carcass and cuts among Ross, Arbor Acres, and Marshall breeds. In the selection process, breeds were characterized and originated specific pedigrees with their own characteristics. Despite that, Hoofman (2005) argued that the genetic base of most commercial breeds are the same and therefore the selection pressures for traits such as performance and carcass yield results in distinct products. Souza *et al.* (1994) showed that some breeds have presented a continuous genetic progress in traits of economic interest. In this evaluation, the breeds Ross, Cobb, Hubbard had a higher breast yield than Arbor Acre breeds. In this way, the evaluation of breeds existing in the market should be periodical, once genetic advantages of economic importance such as breast and leg yield, can change between breeds. The molecular basis incorporated to the selection programs is already being done in order to achieve increasingly faster genetics (Boschiero *et al.,* 2009).

2.5 Genotype and Sex Interactions on Carcass Characteristics of Broilers

Broiler producers generally select strains and sex that reach market body weight early in order to maximize their profit margins (Shim *et al.*, 2012). Genotype and sex interactions effect on body weight, body weight gain, feed intake and feed conversion ratio have been reported by (Shim *et al.*, 2012; Udeh *et al.*, 2015). For example, Udeh *et al.* (2015) observed that Arbor Acre males were superior to males and females of Ross and Marshall. In addition, Olawunmi *et al.* (2012) reported strain x sex interactions on breast, back, thigh, drumstick, wing and leg weights while Ojedapo *et al*. (2008) reported non - significant breed x sex interactions effects on shanks, thigh and drumstick weights, and Olawunmi *et al*. (2012) observed non - significant effects on liver and gizzard weights.

2.6 Effect of Sex on Carcass Characteristics and Internal Organs of Broiler Chickens

Benyi *et al.* (2015) reported that sex significantly affected carcass, back, wing, leg, liver, gizzard, and abdominal fat weights with higher means for males than females for all the traits except abdominal fat weight where females had higher means than males. Kryeziu *et al.* (2015) observed that the breast and whole legs weights of male broilers were significantly higher ($p < 0.05$) compared to those of the female broilers. Akintola *et al.* (2019) reported significant ($p<0.01$) effect of sex on carcass characteristics. Male broilers recorded higher mean values (2558.33g) of live weights, slaughter weight, dress eight and other carcass traits than its female counterpart. Isidahomen *et al*. (2012) reported that male chickens had significantly higher slaughter weight, carcass weight, and dressing percentage than females. Almasi *et al*. (2012) reported that females were fatter than males and suggested that it could be due to the fact that females start to store fat earlier than males. Females start to store fat from 6 weeks compared to 8 weeks in males.

2.7 Effect of Genotype on Carcass and Internal Organs of Broiler Chickens

Benyi *et al.* (2015) reported that sex significantly affected carcass, back, wing, leg, liver, gizzard, and abdominal fat weights with higher means for males than females for all the traits except abdominal fat weight where females had higher means than males. Fernandes *et al.* (2013) recorded significant interactions for breast yield, boned and deboned legs among breeds, sex and slaughter age, and sex being the determinant factor which favors male. Kryeziu *et al.* (2015) observed that the breast and whole legs weights of male broilers were significantly higher ($p < 0.05$) compared to those of the female broilers. Akintola *et al.* (2019) reported significant ($p<0.01$) effect of sex on carcass characteristics. Male broilers recorded higher mean values (2558.33g) of live weights, slaughter weight, dress eight and other carcass traits than its female counterpart.

Isidahomen *et al*. (2012) reported that male chickens had significantly higher slaughter weight, carcass weight, and dressing percentage than females. Young *et al.* (2001) demonstrated that female broilers have higher breast proportions, while in males the proportions of thighs were higher. Mendes *et al.* (2004) established lower abdominal fat percentage in males than females. The authors found that sex also significantly affected carcass traits through slaughter yield, percentages of wings and thigh and meat to bone ratio from the thigh. Castellini *et al.* (2014) reported that carcass characteristics were not greatly affected by sex. Le Bihan-Duval *et al*. (1998) had reported that pullets were fatter than cocks and attributed this to the greater impact of the hormones for fatness in females than males. Almasi *et al*. (2012) reported that females were fatter than males and suggested that it could be due to the fact that females start to store fat earlier than males. Females start to store fat from 6 weeks compared to 8 weeks in males.

2.8 Effect of Genotype and Sex Interactions on Internal Organs and Carcass Characteristics of Broiler Chickens

Genotype × sex interaction effects significantly influenced carcass, breast, back, wing, leg, and liver weights as reported by Benyi *et al.* (2015). Another study, Fernandes *et al. (2013)* reported that carcass and breast fillet yield showed significant differences, independent of breed, sex and slaughter age. Olusegun *et al.* (2020) reported that slaughter weight irrespective of sex and strains significantly influenced carcass yield ($p<0.0001$). Akinsola *et al.* (2019) indicated a significant ($p< 0.01$) effect of strain and sex interactions, and furher established that most carcass traits are sex and strain dependent. Udeh *et al.* (2015) reported that Arbor Acre males were superior to males and females of Ross and Marshall. Olawunmi *et al.* (2012) reported strain x sex interactions on breast, back, thigh, drumstick, wing and leg weights. Also, Olawunmi et *al*. (2012) observed non - significant effects on liver and gizzard weights. Ojedapo *et al*. (2008) reported non - significant breed x sex interactions effects on shanks, thigh and drumstick weights, and Ojedapo *et al*. (2008) observed non - significant interaction effects on gizzard, heart, and abdominal fat weights which implies that there was absence of joint effect of breed and sex on these traits. i.e., the two factors acted independently.

3.0 Methodology of the Study

3.1 Experimental Site

The experiment was carried out between December to March, 2020 at the Poultry unit of Ladoke Akintola University of Technology Teaching and Research Farm, Ogbomoso, Oyo State, Nigeria. It is situated in derived savanna zone of Nigeria on longitude 4°15¹

East of the Greenwich Meridian and latitude 8°15¹ North of the equator. It is about 145km North east of Ibadan, the capital of Oyo state. The mean temperature is about 27°C while the annual mean rainfall is 1247mm (Ewetola *et al.,* 2015).

3.2 Preparation of the Experimental House

The experimental house was constructed with planks, well netted and covered with sacks to reduce cold effect during brooding stage. The experimental house was thoroughly cleaned with detergent and water, disinfected with Lysol and then left to dry for five days prior to stocking. The floor spacing of 45.72cm per bird was covered with new wood shavings up to a thickness of 7cm. All the equipment such as drinkers and feeders were thoroughly cleaned. The pens were heated before the arrival of the birds using coal and electric bulbs as source of heat and light respectively.

3.3 Experimental Birds and Management

A total bird of 150 day-old chicks of three commercial broiler strains comprising of 50 chicks per strain (Arbor Acre, Cobb and Marshall) was used. The birds were purchased from a reputable hatchery with all necessary vaccination and medications administered. Each strain was identified with wing tag and was kept in separate pen in an environmentally controlled brooder house with the floor covered with wood shavings which will be kept dry by replacing soiled litters when required. After 4 weeks, each strain was further sorted based on sex into hen and cock and kept in separate pens.

3.4 Experimental Diet

The birds were fed *ad libitum* on a broiler starter diet (containing 24% CP and 2900kcal/kgME) from 0-4 weeks of age followed by a finisher diet (21% CP and 2800kcal/kgME) to 8^{th} week of age and clean water and will be provided *ad libitum* to the birds.

3.5 Data Collection

At the end of 8 weeks, a total number of 90 birds which comprises of 15 hens and 15 cocks per strain (Arbor Acre, Cobb and Marshall) were slaughtered. The birds were starved overnight and individually weighed to obtain starve live body weight. The birds were stunned and bled by severing the carotid and jugular vein, defeathered and eviscerated (non-edible viscera: intestine, proventriculus, gall bladder, spleen, and full crop). The carcass will then be divided into the following parts as described by Kleezek *et al.,* (2007); head, neck, wing, thigh, drum stick, breast, back. The following parameters were recorded; live weight, defeathered weight, eviscerated weight, carcass weight, dressing weights, weights of cut parts, giblets (heart, liver and empty gizzard), non-edible viscera (intestine, proventriculus, spleen and full crop) and abdominal fat.

3.6 Statistical Analysis

The data collected was subjected to one-way analysis of variance (ANOVA) using the general linear model of (SAS, 2003) where Duncan Multiple Range Test was used to separate significant means. The below model was adopted;

$$Y_{ijk} = \mu + G_i + S_j + (GS)_{ij} + e_{ijk}$$

Where;

Y_{ijk} = The individual measurement on each bird

μ = The overall mean

G_i = Effect of the i^{th} genotype (1,2, 3)

S_j = Effect of the j^{th} sex (1, 2)

$(GS)_{ij}$ = Interaction effect genotype i^{th} and sex j^{th}

e_{ijk} = The random errors.

4.0 Result and Discussion of the Study

4.1 Result of the Study

Table 1 indicated the least square mean of broiler carcass as affected by sex and genotype. Sex had significant ($p<0.05$) effect on all carcass traits measured. Males were heavier in shank (104.23g), thigh(229.57g), breast (458.77g), back (269.60g) and neck (92.40g), while females were heavier in wings (1.00g), drumstick (246.00g) and head (62.20g). Genetic differences ($p<0.05$) existed between the genotypes in carcass traits like shank, wings, thigh, breast, back, drumstick, head and neck. Arbor Acre recorded the highest weights in shank (104.23g), thigh (229.57g), breast (458.77g) and back (269.60g) while Cobb recorded highest weights in wings (197.00g), drumstick (246.00g) and head (62.20g) while Marshall recorded the highest weight in neck (92.40g). Genotype and sex interaction significantly influenced all carcass traits. Arbor Acre male recorded highest weights in shanks (104.23g), thigh (229.57g), breast (458.77) and back (269.60g), Cobb female recorded highest weights in wings (197.00g), drumstick (246.00g) and head (62.20g) and Marshall male recorded the highest weight in neck (92.4g).

Table 2 showed the least square mean of internal organs of broiler chickens as affected by sex and genotype. Sex had significant ($p<0.05$) effect on all internal organs traits measured. Males recorded heavier weights in heart (11.33g), gizzard (39.20g), liver (43.10g), kidney (10.00g), abdominal fat(9.80g), crop (18.50g), lungs (11.73g) while female were heavier in proventriculus (43g), spleen (2.16g) and intestinal offal (125.80g). The internal organs also reflected significant ($p<0.05$) difference between the genotypes in all traits except abdominal fat. Arbor Acre recorded the highest weight in heart (11.33g), liver (43.10g), spleen (2.16g), intestinal offal (125.80g), crop (18.50g) and lungs (11.73g), Cobb had the highest weights in proventriculus (43g) and kidney (10.00g) and Marshall recorded the highest weight for gizzard (39.20g). Genotype and sex interaction significantly ($p<0.05$) affected all the internal organs except abdominal fat. Arbor Acre male recorded the highest weights in heart (11.33g), liver (43.10g), spleen (2.16g), intestinal offal (125.80g), crop (18.50g) and lungs (11.73g) while Cobb female recorded the highest weights in proventriculus (43g), Cobb male recorded highest weights in kidney (10.00g) and Marshall Male recorded highest weights in gizzard (39.20g).

Table 1. Least square means of broilers carcass as affected by sex and genotype

Traits (g)	Sex	Arbor Acre	Cobb	Marshall
Wings	M	183.80±0.71^{a}	150.80±2.03^{b}	140.80±0.46^{c}
	F	140.00±1.67^{b}	197.00±1.10^{a}	131.60±2.32^{c}
Shanks	M	104.23±6.92^{a}	73.80±0.97^{b}	68.20±1.77^{c}
	F	66.40±0.51^{b}	87.20±0.98^{a}	56.60±0.69^{c}
Thigh	M	229.57±1.71^{a}	180.40±2.40^{c}	215.80±1.70^{b}
	F	182.40±2.10^{b}	223.20±3.35^{a}	172.20±2.31^{c}
Drumstick	M	224.17±4.39^{a}	193.40±1.70^{b}	213.80±2.38^{a}
	F	179.60±0.71^{b}	246.00±1.58^{a}	145.80±1.99^{c}
Breast	M	458.77±7.23^{a}	363.00±5.15^{b}	360.20±3.06^{c}
	F	366.40±1.64^{b}	454.80±0.71^{a}	257.00±5.07^{c}
Back	M	269.60±3.20^{a}	196.44±13.51^{c}	248.00±5.13^{b}
	F	204.80±1.10^{c}	267.80±1.76^{a}	227.00±3.45^{b}
Neck	M	81.07±1.46^{b}	68.80±1.88^{c}	92.40±0.55^{a}
	F	57.60±1.03^{c}	81.00±1.34^{a}	66.60±0.45^{b}
Head	M	53.27±0.24^{a}	47.60±0.93^{b}	42.80±0.64^{c}
	F	37.40±0.77^{c}	62.20±0.28^{a}	42.80±0.49^{b}

^{abc}Means along the same row with different superscripts are significantly ($p<0.05$) different

M = male, F = female

Table 2: Least square means of internal organs of broilers as affected by sex and genotype

Internal organ (g)	Sex	Arbor Acre	Cobb	Marshal
Proventriculus	M	9.43±0.21 ^{b}	9.80±0.26 ^{a}	9.00±0.12 ^{c}
	F	8.20±0.07 ^{c}	10.40±0.19 ^{a}	9.60±0.39 ^{b}
Heart	M	11.33±0.24 ^{a}	7.20±0.21 ^{c}	8.20±0.34 ^{b}
	F	6.80±0.14 ^{b}	7.80±0.06 ^{a}	6.80±0.22 ^{b}
Gizzard	M	30.50±0.09 ^{b}	30.40±0.50 ^{b}	39.20±0.70 ^{a}
	F	28.40±0.42 ^{b}	37.60±0.95 ^{a}	28.60±0.19 ^{b}
Liver	M	43.10±0.67 ^{a}	39.00±0.31 ^{b}	37.20±0.61 ^{c}
	F	38.80±0.30 ^{a}	38.00±0.18 ^{a}	32.80±0.66 ^{b}
Spleen	M	1.12±0.15 ^{a}	1.24±0.12 ^{a}	1.16±0.06 ^{a}
	F	2.16±0.08 ^{a}	2.00±0.01 ^{b}	1.04±0.11 ^{c}
Kidney	M	9.57±0.33 ^{b}	10.00±0.24 ^{a}	6.80±0.14 ^{c}
	F	7.80±0.80 ^{b}	8.40±0.15 ^{a}	6.80±0.14 ^{c}
Intestinal offal	M	121.50±0.33 ^{a}	120.80±0.41 ^{b}	112.60±3.23 ^{c}
	F	125.80±0.66 ^{a}	116.20±1.18 ^{b}	78.00±0.85 ^{c}
Abdominal fat	M	9.80±0.27 ^{a}	9.80±0.51 ^{a}	9.40±0.48 ^{a}
	F	8.80±0.22 ^{a}	1.00±0.13 ^{c}	7.80±0.85 ^{b}
Crop	M	18.50±1.92 ^{a}	11.80±0.41 ^{b}	9.40±0.25 ^{c}
	F	17.40±0.84 ^{a}	10.80±0.46 ^{b}	7.00±0.20 ^{c}
Lungs	M	11.73±0.08 ^{a}	10.00±0.33 ^{b}	9.20±0.22 ^{c}
	F	8.40±0.22 ^{b}	10.20±0.17 ^{a}	6.80±0.14 ^{c}

[abc]Means along the same row with different superscripts are significantly ($p<0.05$) different

M = male, F = female

4.2 Discussion of the Study

The current trend of this study showed that sex had a significant ($p<0.05$) effect on internal organs and carcass traits of broiler chickens. Benyi et al. (2015) reported that sex significantly affected carcass, back, wing, leg, liver, gizzard, and abdominal fat weights with higher means for males than females for all the traits except abdominal fat weight where females had higher means than males. Fernandes *et al.* (2013) recorded significant interactions for breast yield, boned and deboned legs among breeds, sex and slaughter age, and sex being the determinant factor which favors male. Kryeziu *et al.* (2015) observed that the breast and whole legs weights of male broilers were significantly higher ($p < 0.05$) compared to those of the female broilers. Akintola *et al.* (2019) reported significant ($p < 0.01$) effect of sex on carcass characteristics. Male broilers recorded higher mean values (2558.33g) of live weights, slaughter weight, dress eight and other carcass traits than its female counterpart. Isidahomen *et al*. (2012) reported that male chickens had significantly higher slaughter weight, carcass weight, and dressing percentage than females.

In contrary, Young *et al.* (2001), demonstrated that female broilers have higher breast proportions, while in males the proportions of thighs were higher. Mendes *et al.* (2004), established lower abdominal fat percentage in males than females. The authors found that sex also significantly affected carcass traits through slaughter yield, percentages of wings and thigh and meat to bone ratio from the thigh. Castellini *et al.* (2014), reported that carcass characteristics were not greatly affected by sex. Le Bihan-Duval *et al*. (1998) had reported that pullets were fatter than cocks and attributed this to the greater impact of the hormones for fatness in females than males. Almasi *et al*. (2012) reported that females were fatter than males and suggested that it could be due to the fact that females start to store fat earlier than males. Females start to store fat from 6 weeks compared to 8 weeks in males. The results of the study also showed that genotype significantly ($p<0.05$) affected all internal organs and carcass traits except abdominal fat. Arbor Acre had the highest carcass and internal organ yields in comparison to Cobb and Marshall. Olusegun *et al.* (2020), reported that Arbor Acre had the highest carcass yields for all slaughter weights than Anak and Ross. Olawumi & Fagbuaro (2011) observed that genotype had significant effects on carcass characteristics such as carcass fatness, meat quality, carcass weight, breast and leg muscle weight, fats and edible giblet weight and back and drumstick weights. Marcu *et al.* (2013) observed that genotype influences carcass yield ($p\leq 0.01$) like breast, thighs and legs. Fernandes et *al.* (2013) observed carcass and breast fillet yield showed significant differences, independent of breed, sex and slaughter age, highlighting Cobb breeds.

Udeh *et al.* (2015) found no difference in the yield of carcass and cuts among Ross, Arbor Acres, and Marshall breeds. In the results of Fernandes *et al*. (2013), the authors evaluated the carcass yields of Ross, Cobb, Hubbard, and Arbor Acres and observed no significant differences in yield but Ross, Cobb, and Hubbard deposited more abdominal fat than Arbor Acres. The authors also observed that Benyi *et al.* (2015) reported that as regards carcass characteristics, genotype affected only liver weight with a heavier liver in Cobb than Ross. Kokoszynski *et al.* (2020) reported that chicken's genotype has no significant effect on percentage of internal organs i.e. liver heart, proventriculus, gizzard and spleen. Genotype and sex interaction affected all carcass and internal organs traits. As with the performance traits, these interactions were caused by the differential responses of the genotypes to the male and female environments. This agrees with Udeh *et al.* (2015) that Arbor Acre males were superior to males and females of Ross and Marshall. In addition, Olawunmi *et al.* (2012) reported strain x sex interactions on breast, back, thigh, drumstick, wing and leg weights.

Benyi *et al.* (2015) stressed that genotype × sex interaction effects significantly influenced carcass, breast, back, wing, leg, and liver weights. Akinsola *et al.* (2019) indicated a significant ($p< 0.01$) effect of strain and sex interactions, and further established that most carcass traits are sex and strain dependent. Fernandes *et al. (2013)* reported that carcass and breast fillet yield showed significant differences, independent of breed, sex and slaughter age. Olusegun *et al.* (2020) reported that slaughter weight irrespective of sex and strains significantly influenced carcass yield ($p<0.0001$). Also, Olawunmi *et al*. (2012) observed non - significant effects on liver and gizzard weights. Ojedapo *et al*. (2008) reported non - significant breed x sex interactions effects on shanks, thigh and drumstick weights, gizzard, heart, and abdominal fat weights which implies that there was absence of joint effect of breed and sex on these traits. i.e., the two factors acted independently.

5.0 Conclusion of the Study

The overall results of this study have shown that genotypes differed significantly in carcass and internal organs traits, with Arbor Acre having highest weight values in all carcass and internal organs traits except wings, drumstick, head, neck, proventriculus, kidney and gizzard. Also, males recorded the heaviest weights in all carcass and internal organs trait except wings, drumstick, head, proventriculus, spleen and intestinal offal. There was a significant interaction between genotype and sex in both carcass and internal organs traits except abdominal fat. Arbor Acre male was highly favored recording the highest weight values both for internal organs and carcass cut-up parts except drumstick, head, neck, proventriculus, kidney, spleen, gizzard and intestinal offal. From the result obtained in this study, Arbor Acre male is therefore recommended for profitable broiler production because it recorded the highest carcass and internal organ traits yield.

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7.0 Reference of the Study
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