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Breed and Sex Differences in the Gross Anatomy, Digesta pH and Histomorphology of the Gastrointestinal Tract of Gallus Gallus Domesticus

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ABSTRACT

A study was conducted to investigate the influence of breed and sex in the gross anatomy, digesta and histology of Ross 308 broiler and Venda chickens. Chickens were slaughtered at 90 days of age and the pH of the digestive organs was measured immediately after slaughter. The digestive organ weights and lengths of Ross 308 broiler and Venda chickens were measured. Tissue samples of the duodenum, ileum and jejunal from each treatment group were collected and histologically examined. Higher ($p<0.05$) gizzard pH values were observed in male and female of Ross 308 broiler and Venda chickens. The jejunal and ileal pH values were lower ($p<0.05$) for Venda chickens than in Ross 308 broiler chickens. The absolute weights of the gastrointestinal tract, crop, proventriculus and gizzard were lighter ($p<0.05$) in Venda chickens than in Ross 308 broiler chickens. The relative organ weights of the GIT, proventriculus, gizzard and caeca were higher ($p<0.05$) in Venda chickens than in Ross 308 broiler chickens aged 90 days. Male chickens had higher ($p<0.05$) relative organ weights than female chickens. Interactions between breed and sex influenced ($p<0.05$) the absolute weights of the crop, proventriculus, caeca and large intestine. Ileum villus heights of female Venda chickens were higher ($p<0.05$) than those of female and male Ross 308 broiler and Venda chickens. The male and female Ross 308 broiler chickens had higher ($p<0.05$) ileum and duodenum crypt depths than male and female Venda chickens. The duodenum and ileum villus height/crypt depth ratios were higher ($p<0.05$) in male and female Venda chickens than Ross 308 broiler chickens. In overall, male broiler chicken performed better.

INTRODUCTION

The *Gallus gallus* species commonly known as the broiler chicken has a fast growth rate that is influenced by intestine development (Smith *et al*., 2004). Their small intestines grow fast in terms of weight than carcass mass, and the small intestine's relative growth peaks between 6 to 10 days of age (Mateo *et al*., 2004). The growth and increase of the gastrointestinal tract (GIT) stimulates the feed intake (Gracia *et al*., 2003) and the duodenum develops earlier than the jejunum and ileum (Uni *et al*., 1999). The rate of development of the GIT of *Gallus domesticus* (indigenous chickens) has not been extensively researched. These slow growing breeds are known to have a slow development of the gastrointestinal tract compared to the fast growing broiler chickens (Mabelebele *et al*., 2014). The length and weight of digestive organs of indigenous chickens are shorter and weigh less compared to those of broiler chickens (Khadhin *et al*., 2010; Kras, 2013). This has implications on the digestion and absorption of nutrients which in turn affect the body weight gain of indigenous chickens.

The health condition, type of nutrients consumed affects the level of alkalinity and acidity in the digestive system of the chickens (Rahmani *et al*., 2005). The pH level in certain parts of the GIT influences the growth of microbes, which affects feed digestion and nutrients absorption. Amount and type of fibre plays an important role on organ size and pH of the GIT of birds (Jimenez-Moreno *et al*., 2009). The GIT of fast growing Ross 308 broiler chickens develop and mature faster than those of the slow growing indigenous chickens (Jamroz, 2005). Ross 308 broiler chickens have been bred for high feed conversion ratio and growth rate (Krás *et al.,* 2013). This has resulted in changes in the anatomy and function of the digestive system. The length and weight of the small intestines vary between the different species of birds (Hassouna *et al.,* 2001). The villus height and mucosa thickness are commonly used as good indicators for evaluating and understanding the intestinal status which is linked to the absorptive functions (Incharoen, 2013) of chickens. Morphology and histology of the gastrointestinal tract of Ross 308 broiler chickens were described and studied by Hassouna (2001) and Nasrin *et al*. (2010). Very little research has been done on the digestive organ pH between Ross 308 broiler and indigenous Venda chickens (Mabelebele *et al*., 2014). However, no data was recorded on the histology of the GIT of Ross 308 broiler and indigenous Venda chickens. Therefore, the objective of this study was to determine the gross anatomy and digesta organ pH in the gastrointestinal tract of Ross 308 broiler and indigenous Venda chickens fed the same diet and raised under similar conditions.

MATERIALS AND METHODS

Study site, experimental design and treatments

A total of 120 day-old chicks, 60 Ross 308 broiler chickens (530 ± 2 g) and 60 indigenous Venda chickens (462 ± 10 g), in a completely randomized design each breed replicated five times were used in this study. Feed and water were provided *ad libitum*, continuous lighting schedule was used throughout the experimental period. Chickens were fed a standard commercial diet for 91 days and the experimental diet was isocaloric and isonitrogenous (Table 1).

Table 1 – Ingredients and nutrient contents of starter, grower, and finisher diets

Ingredients (g/kg)	Starter	Grower	Finisher
Corn yellow	646.72	672.53	738.43
SBM, Arg 2400-45.2	244.50	156.21	140.97
Canola ml solvent 2000-37	32.37	50.00	10.00
Meat meal 59 UMo	44.64	87.31	79.39
Canola oil	7.50	12.75	15.43
Limestone	8.18	2.36	2.46
Dical phos 18P/21Ca	3.52	0.01	0.01
Salt	1.04	0.597	0.72
Na bicarb	1.04	1.88	8.900
Vitamin mineral premix 2 kg/mt	2.00	2.00	0.2000
Choline Cl 70%	0.74	1.28	0.1164
L-lysine HCl 78.4	4.03	4.04	0.3812
DL-methionine	1.53	1.81	0.1685
L-threonine	1.98	1.98	0.1682
Chemical composition (g/kg)			
Metabolizable energy (MJ/kg)	12.55	12.97	13.39
Crude protein	230.0	215.0	195.0
Crude fibre	25.0	24.47	22.2
Crude fat	36.0	45.5	47.9
Digestible arginine	12.3	11.1	9.84
Digestible lysine	12.5	11.5	10.2
Digestible methionine	4.5	4.7	4.3
Digestible methionine+ cysteine	7.3	7.0	6.3
Digestible leucine	17.4	9.0	7.4
Digestible tryptophan	2.3	1.7	1.5
Calcium	10.0	8.7	7.8
Available phosphorus	5.0	4.35	3.9
Potassium	8.7	2.3	6.6
Chloride	2.3	1.6	2.3
Sodium	1.6	1.6	1.6
Choline (mg/kg)	1700	1600	1500

† The active ingredients contained in the vitamin–mineral premix were as follows (per kg of diet): vitamin A – 12000 IU, vitamin D3 – 3500 IU, vitamin E – 30 mg, vitamin K3 – 2.0 mg, thiamine – 2 mg, riboflavin – 6 mg, pyridoxine – 5 mg, vitamin B12 – 0.02 mg, niacin – 50 mg, pantothenate – 12 mg, biotin 0Æ01 mg, folic acid – 2 mg, Fe – 60 mg, Zn – 60 mg, Mn – 80 mg, Cu – 8 mg, Se – 0Æ1 mg, Mo – 1 mg, Co – 0Æ3 mg

Gross anatomy and digesta organ pH determination

After 90 days of ages, ten chickens from each breed and sex were randomly taken and killed by cervical dislocation then scalded and defeathered according to the University of Limpopo Animal Ethics Committee (TREC/12/2014:IR). The gastrointestinal tract of each chicken breed was eviscerated and immediately placed on a tray at room temperature then gently uncoiled to avoid tearing or stretching. The pH was measured with a calibrated digital pH meter (model IQ120, 2075E Corte Del Nogal, Carlsbard, CA, USA). In a sequential manner, the pH values for different segments of the gastrointestinal tract were measured by inserting a glass electrode directly in the opening made in the organs with digesta during the slaughter (Mabelebele *et al*., 2014). In order to evaluate organ weights and intestinal morphometrics of the male and female chickens at 90 days of age, the gizzard, proventriculus, small intestines and the large intestines, including the

caeca, were collected and weighed immediately at both 42 and 90 days. A measuring tape and RADWAG digital scale (Model PS 750/C/2) were used to measure the lengths and weights respectively. The gizzard was thus, weighed after its contents were removed and cleaned. Small and large intestines were cleaned of any contents and weighed in segments. Body weights of the chickens were taken before slaughter. Relative organ weight and length of male and female Ross 308 broiler and Venda chickens were expressed as a percentage of the live weight.

Histology analysis

Ten birds were randomly selected from each breed and sex, slaughtered by cervical dislocation to obtain tissue samples for microscopic assessment. Segments measuring approximately 3.0 cm of the duodenum (from the gizzard to pancreatic and bile duct), jejunum (from the bile duct to Meckel's diverticulum) and ileum (from the Meckel's diverticulum to ileo-caecalcolonic junction) were cut according to Samanya and Yamauchi (2002) from each chicken at 90 days of age. The samples were washed in phosphate buffer solution at 0.1 M (pH 7.4) and fixed in Bouin solution for three days. The samples were then trimmed to eliminate the torn edges, and remained for further 24 hours in the fixing solution. The samples were washed in ethanol at 70% to remove the fixing solutions, dehydrated in graded series of alcohol and cleaned in xylol. Four semi-serial sections with 7-cm thickness were placed in each slide. The method of the periodic acid of Schiff (PAS) was used to dye the slides. Villi height and crypt depths were in all the segments of the small intestines using an image capture and analysis system (Image J, 1.47r). Villus height was measured from the basal region, which starts at the higher portion of the crypt, until villus tip, whereas crypt depth was measure from the base up to the crypt-villi transition region (Carrijo *et al.,* 2005).

Statistical analysis

Data on organ weights and length, digesta organ pH and histology of the GIT of both the Ross 308 broiler and Venda chickens were analysed using the General Linear Model (GML) procedure of the statistical analysis of variance (SAS, 2008). The following statistical model was used for data analysis:

$$Y_{ij} = \mu + B_i + S_j + (B \times S)_{ij} + e_{ij}$$

Where,

Y_{ij} is the observation on the 1^{th} replication of the i^{th} breed and j^{th} sex.

μ is the overall mean

B_i is the fixed effect of i^{th} breed (i=1,2)

S_j is the fixed effect of j^{th} sex (j=1,2)

$(B \times S)_{ij}$ is the interaction of i^{th} breed and j^{th} sex

e_{ij} is the random error

RESULTS

The results of the breed and sex effect on the digestive organ pH of Ross 308 broiler and Venda chickens aged 90 days are presented in Table 2. Breed and sex had no significant influence ($p>0.05$) on crop, proventriculus and duodenum pH values of Ross 308 broiler and Venda chickens. However, Gizzard pH values of Ross 308 broiler chickens were lower ($p<0.05$) than those of Venda chickens. The jejunum and ileum pH values were found to be lower ($p<0.05$) for Venda chickens than those observed in Ross 308 broiler chickens. Additionally, male chickens (of both genotypes) had higher ($p<0.05$) jejunum pH values than female chickens.

Table 2 – Breed and sex effects on the digestive organ pH of Ross 308 broiler and Venda chickens aged 90 days of age

Treatment	Crop	Proventriculus	Gizzard	Duodenun	Jejunum	Ileum
Breed						
Ross308	4.80	4.39	3.22[b]	5.89	6.20[a]	6.64[a]
Venda	4.63	4.58	3.79[a]	5.86	5.44[b]	5.78[b]
SEM	0.086	0.071	0.085	0.019	0.038	0.107
Sex						
Female	4.54	4.54	3.51	5.87	5.76[b]	6.23
Male	4.88	4.43	3.50	5.88	5.89[a]	6.20
SEM	0.086	0.071	0.085	0.0190	0.038	0.107
Probability						
Breed	0.1734	0.0633	<.0001	0.1733	<.0001	<.0001
Sex	0.0582	0.2793	0.9803	0.5783	0.0233	0.8389
Breed*Sex	0.2691	0.5083	0.0871	0.1070	0.8538	0.3384

SEM: Standard error of means

[a,b]: Means in the same column with different superscripts are significantly different ($p<0.05$)

The live and carcass weights, absolute and relative organ weights of Ross 308 broiler and Venda chickens aged 90 days are presented in Tables 3 and 4. The live and carcass weights of Ross 308 broiler chickens were superior ($p<0.05$) than those of Venda chickens. The absolute weights of the GIT, crop, proventriculus, gizzard, small intestine, caeca and large intestines of Venda chickens were lighter ($p<0.05$) than in Ross 308 broiler chickens. Relative weights of the GIT, proventriculus, gizzard and ceca were higher ($p<0.05$) in Venda chickens than in Ross 308 broiler chickens aged 90 days (Table 4). No significant differences ($p>0.05$) were observed in Ross 308 broiler and Venda chickens' crop, small intestines, duodenum, jejunum, ileum and large intestines organ weight relative to carcass weight. Sex did not influence the absolute ileum weights of Ross 308 broiler and Venda chickens ($p>0.05$). However, sex influenced all relative organ weights of Ross 308 broiler and Venda chickens ($p<0.05$). Interactions of breed and sex influenced ($p<0.05$) the absolute crop, proventriculus, caeca and large intestine weights. However, breed and sex interaction did not affect the absolute weights of live and carcass weights, GIT, small intestine, duodenum, ileum and jejunum ($p>0.05$). Traits such as crop, proventriculus, gizzard, small intestine, duodenum and large intestine relative weights were influenced ($p<0.05$) by breed and sex interaction. There were no breed and sex interactions observed on the relative weights of GIT, jejunum, ileum and caeca ($p>0.05$).

The absolute and relative organ length of broiler and Venda chickens are presented in Tables 5 and 6. The GIT length were longer ($p<0.05$) for Ross 308 broiler than Venda chickens. Similarly, male chickens had longer ($p<0.05$) GIT than their female counterparts.

Table 3 – Live and carcass weight and absolute organ weight (g) of Ross 308 broiler and Venda male and female chickens aged 90 days

Variables	Breed		SEM	Sex		SEM	Probability		
	Ross308	Venda		Female	Male		Breed	Sex	Breed*Sex
Live weight	2861.8^{a}	1308.9^{b}	58.99	1903.1^{b}	2267.6^{a}	58.987	0.000	0.0007	0.0650
Carcassweight	2105.8^{a}	807.3^{b}	51.30	1306.10^{b}	1607.0^{a}	51.299	0.000	0.0011	0.4170
GIT	2105.8^{a}	807.3^{b}	3.27	80.54^{b}	176.93^{a}	3.2671	0.000	0.000	0.0715
Crop	16.9^{a}	8.2^{b}	0.94	11.117^{b}	13.915^{a}	0.9436	0.000	0.0512	0.0398
Proventriculus	11.4^{a}	7.1^{b}	0.34	8.509^{b}	10.040^{a}	0.3371	0.000	0.0071	0.0326
Gizzard	53.8^{a}	35.8^{b}	2.08	40.391^{b}	49.171^{a}	2.0750	0.000	0.0109	0.0900
Small intestine	78.5^{a}	45.0^{b}	6.07	51.482^{b}	71.976^{a}	6.0662	0.0018	0.0350	0.0807
Duodenum	23.8^{a}	10.3^{b}	4.36	13.085^{b}	20.970^{a}	4.3560	0.0503	0.0234	0.1287
Jejunum	25.5^{a}	13.9^{b}	1.77	15.790^{b}	23.584^{a}	1.7728	0.0004	0.0276	0.6907
Ileum	26.0^{a}	20.3^{b}	1.50	21.089^{b}	25.232^{a}	1.4983	0.0189	0.0074	0.1545
Caeca†	7.4^{a}	10.3^{b}	0.58	8.9580^{b}	8.7723^{a}	0.5771	0.0036	0.0082	0.0393
Large intestine	28.9^{a}	13.6^{b}	1.923	17.846^{b}	24.675^{a}	1.9252	0.0001	0.0279	0.0009

SEM: Standard error of means

^{a,b}: Means in the same row with different superscripts are significantly different

†: An average value of each caeca pair

Table 4 – Relative organ weight (%) of Ross 308 broiler and Venda male and female chickens aged 90 days

Variables	Breed		SEM	Sex		SEM	Probability		
	Ross308	Venda		Female	Male		Breed	Sex	Breed*Sex
GIT	7.598^{b}	11.380^{a}	0.4308	6.924^{b}	12.054^{a}	0.4308	0.0000	0.0000	0.7217
Crop	0.7918^{b}	1.0219^{a}	0.0580	0.9265^{a}	0.8872^{b}	0.058	0.0072	0.0068	0.0118
Proventriculus	0.5423^{b}	0.8912^{a}	0.0261	0.7341^{a}	0.6994^{b}	0.0261	0.0000	0.0372	0.0038
Gizzard	2.5455^{b}	4.4648^{a}	0.1189	3.5352^{a}	3.4751^{b}	0.1189	0.0000	0.0073	0.0465
Small intestine	3.6807^{b}	5.5923^{a}	0.3119	4.4698^{b}	4.8032^{a}	0.3119	0.0008	0.0001	0.0218
Duodenum	1.1140^{b}	1.2861^{a}	0.2071	1.1585^{b}	1.2416^{a}	0.2071	0.0057	0.0056	0.0186
Jejunum	1.2275^{b}	2.2050^{a}	0.1552	1.7985^{a}	1.6340^{b}	0.1552	0.0006	0.0042	0.3421
Ileum	1.1984^{b}	1.9083^{a}	0.1106	1.2609^{b}	1.8458^{a}	0.1106	0.0005	0.0025	0.3011
Caeca†	0.3620^{b}	1.2795^{a}	0.0505	0.8783^{a}	0.7632^{b}	0.0505	0.0000	0.0007	0.9183
Large intenstine	1.3433^{b}	1.7252^{a}	0.1014	1.5992^{a}	1.4693^{b}	0.1014	0.0208	0.0059	0.3003

†: An average value of each caeca pair

SEM: Standard error of means

^{a,b}: Means in the same row with different superscripts are significantly different

Table 5 – Absolute organ length (cm) of Ross 308 broiler and Venda male and female chickens aged 90 days

Variables	Breed		SEM	Sex		SEM	Probability		
	Ross308	Venda		Female	Male		Breed	Sex	Breed*Sex
GIT	208.82[a]	138.78[b]	8.0887	169.61[b]	177.99[a]	8.0867	0.0001	0.0474	0.0314
Smallintestine	179.08[a]	114.25[b]	8.1068	136.40[b]	156.93[a]	8.1068	0.0001	0.0093	0.1479
Duodenum	34.850[a]	22.590[b]	1.4884	27.380[b]	30.060[a]	1.4884	0.0001	0.0010	0.0027
Jejunum	64.610[a]	39.020[b]	2.4265	47.680[b]	55.950[a]	2.4265	0.0001	0.0284	0.0419
Ileum	89.530[a]	57.110[b]	2.3902	73.670[a]	72.970[b]	2.3902	0.0001	0.0086	0.5858
Caeca†	22.880[a]	17.540[b]	0.5430	19.890[b]	20.530[a]	0.5430	0.0000	0.0114	0.0042
Large intestine	39.020[a]	11.550[b]	4.2984	26.190[a]	24.350[b]	4.2984	0.0734	0.0079	0.0582

†: An average value of each caeca pair
SEM: Standard error of means
[a,b]: Means in the same row with different superscripts are significantly different

Table 6 – Relative organ length (cm organ/100g Carcass weight) of male and female Ross 308 broiler and Venda chickens aged 90 days

Variables	Breed		SEM	Sex		SEM	Probability		
	Ross308	Venda		Female	Male		Breed	Sex	Breed*Sex
GIT	9.994[b]	17.309[a]	0.7862	15.063	12.241[b]	0.7862	0.0000	0.0219	0.0435
Small intestine	45.9[b]	37.8[a]	9.4830	72.8	10.8[b]	9.4830	0.4053	0.0001	0.7271
Duodenum	1.6685[b]	2.8020[a]	0.1202	2.4765	1.9940[b]	0.1202	0.0000	0.0118	0.0834
Jejunum	3.0868[b]	4.8052[a]	0.1583	3.9507	3.9414[b]	0.1583	0.0000	0.0096	0.1852
Ileum	4.3277[b]	7.0598[a]	0.1696	6.2105	5.15570[b]	0.1696	0.0000	0.0005	0.0073
Caeca†	1.1050[b]	2.1705[a]	0.0592	1.7431	1.5323[b]	0.0592	0.0000	0.0229	0.0160
Large intestine	1.9080[a]	1.4330[b]	0.2433	1.8683	1.4727[b]	0.2433	0.0186	0.02671	0.4443

†An average value of each caeca pair
SEM: Standard error of means
[a,b]Means in the same row with different superscripts are significantly different

The histological parameters of the different small intestines of male and female Ross 308 broiler and Venda chickens are shown in Figures 1 A, B and C. Ileum villi height from female Venda chickens were higher ($p<0.05$) than those of female Ross 308 broiler, males Ross 308 broiler and Venda chickens. The male and female Ross 308 broiler chickens had higher ($p<0.05$) ileum and duodenum crypt depths than male and female Venda chickens. The duodenum and ileum villi height/crypt depth ratio were higher ($p<0.05$) in male and female Venda chickens than Ross 308 broiler chickens. Breed and sex interactions influenced (51.491±0.0001; 69.020±0.0005) the ileum villus heights. Ileum villi height to crypt depth ratio were higher ($p<0.05$) in Venda chickens than Ross 308 Venda chickens. Male and females of Venda chickens had higher ($p<0.05$) ileum villi height to crypt depth ratio than in male and female of Ross 308 broiler chickens. Breed and sex interactions ($p>0.05$) were observed in duodenum and jejunum crypt depth and villus height/crypt depth ratio.

DISCUSSION

In the current study, gizzard pH was more acidic in male and female of Ross 308 broiler than in male and female of Venda chickens. The above findings are contrary to those reported by Mabelebele *et al.* (2014) that Venda chickens had lower gizzard pH values than Ross 308 broiler chickens at 90 days of age. Low pH in the gut of the chickens is usually correlated with increased mineral salt solubility, and this may promote pepsin activity and improve the digestion and absorption of minerals in the upper part of the gastrointestinal tract (Incharoen, 2013). Male and female Venda chickens in the current study were reported to have lower pH values in the jejunum and ileum than values reported in Ross 308 broiler chickens. Indigenous chickens have an ability to support acidic conditions in their intestines. This may have been an adaptive approach to utilizing diets low in nutrient content. Absolute organ weights and lengths were observed to be higher in Ross 308 broiler than Venda chickens. These results were supported by Khadhin *et al.* (2010) who observed that broiler chickens had higher absolute organ weights than those in Malaysian village fowl. The absolute weights of the intestinal segments (duodenum, jejunum and ileum) were heavier for Ross 308 broiler than in Venda chickens. Perhaps these differences can be due to the obvious differences in carcass weight, growth rate and feed intake between the fast and slow growing chickens (Khadhin *et al.*, 2010).

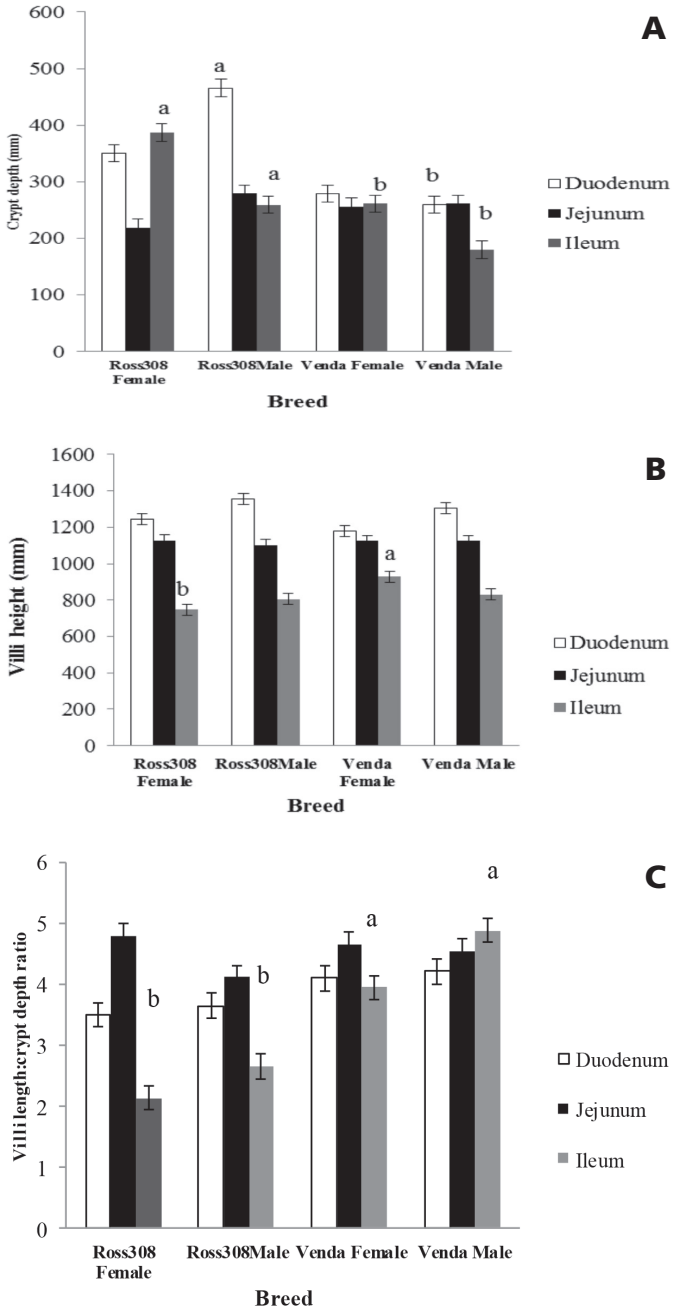

Figure 1 – Duodenum, jejunum and ileum villi heights (A), crypt depths (B) and villi height: crypt depth ratios (C) of male and female Ross 308 broiler and Venda chickens; [a,b] :Means in the same bar with different superscripts are significantly different.

These authors went further to elaborate that the selection process done for the broiler chicken for feed efficiency affects the total size and development of the whole GIT. The organ weight relative to carcass weight of the entire GIT, proventriculus, gizzard and caeca were higher for Venda chickens than broiler chickens. The above findings were similar to those observed by Santos *et al*. (2005). The relative gizzard weight was higher for Venda chickens than broiler chickens, with female having higher relative weight than males. This is contrary to the finding of Figuiredo *et al.* (2002) who reported that males of four strains had higher relative gizzard weights whereas Santos *et al*. (2006) indicated that no differences in relative gizzard weight were observed between sexes. The absolute and relative organ weights of broiler chickens were reported to be heavier than in Venda chickens. Male chickens exhibited longer absolute and relative organ length than female chickens. The above findings are supported by Khadhin *et al.* (2010) who reported that light breed chickens have lighter and shorter intestines than the heavy breeds. However, the duodenum absolute and relative length was affected by neither sex nor breed. The results of the dimorphic comparison of the organ weights and length of the two breeds clearly indicated that they were superior for males than females in the current study and also related studies by Mobini *et al.* (2011) for broiler chickens, Ankney & Afton (1988) in Shoveler *Anas clyeata*, Miller (1974) in Mallard *Anas platyhynchos* and Pullianen (1976) in Willow Grouse *Lagopus lagopus.* These authors also elaborated that the morphometric results show a strong dependency of intestinal growth (all parameters) on carcass weight. It was also suggested that the fact that females have lighter and shorter digestive organs may better adjust them to changing in feeding conditions than those of males. Longer intestines which were observed in males and females of broiler chickens are associated with ability to digest feed efficiently and provide greater surface area for nutrient absorption. This in turn assists in faster growth rate that is observed in these breeds than slow growing breeds.

Ileum villus heights of female Venda chickens were higher than those of female Ross 308 broiler and males Ross 308 broiler and Venda chickens. These findings are contrary to those reported by Khadhin *et al.* (2010) who indicated that villus height for all the intestinal segments were higher for broiler chickens than Malaysian village fowl. The current findings also debunk the hypothesis that differences between the histological parameters of fast and slow growing chickens are supported by metabolic carcass weight, and therefore, absorptive surfaces of the small intestines are directly related to metabolic requirements (Mayhew and Middleton, 1985). Furthermore, contrary to the current findings, James *et al.* (1988); Smith *et al.* (1990) and Khadhin *et al.* (2010) reported that the presentation of nutrients within the small intestine constitutes one of the most potent ways to modify villus structures for different groups of chickens selected for higher growth rate. Numerically, the duodenum had the highest villi height followed by jejunum and the lowest heights were observed for the ileum in the current study in

both breeds and sexes, which is in agreement with the findings of Khadhin *et al.* (2010), Yamauchi (2002) and Lidia *et al.* (1998). The male and female Ross 308 broiler chickens had higher ileum and duodenum crypt depths than male and female Venda chickens. The duodenum and ileum villus height/ crypt depth ratios were higher in male and female Venda chickens than in Ross 308 broiler chickens, this may also be an adaptive feature that enables indigenous chickens to effectively utilize diets with low nutrient content.

CONCLUSION

Results of the present study indicate that breed and sex differences exist. It was evidenced that the slow growing indigenous Venda chickens have a lower carcass weight than Ross 308 broiler chickens. Sex differences were also found. Male chickens are heavier than females regardless of the breed. Digestive organs of Ross 308 chickens had higher weights and the GIT were longer than in Venda chickens. This gives the GIT of Ross 308 chickens a higher capacity for digestion and absorption of nutrients, thus, they attain higher carcass weights. Ileal villi length was higher in indigenous Venda chickens, however, this did not translate to better growth performance than the Ross 308 chickens. The effect of genotype tends to limit the performance of indigenous Venda chickens, crossbreeding could be a way to improve the productive performance and be further investigated. It is inferred that phylogeny and not diet may be the main factor influencing anatomy of the digestive system, digesta pH and histomorphology as both chicken breeds were fed a similar diet.

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