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Carcass Characteristics of Guinea Fowl Raised under Intensive System and Fed Diets Containing Yellow Maize, Millet and White *Sorghum* as Energy Sources

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Abstract

This study investigated carcass characteristics of guinea fowl reared under intensive system and fed diets containing yellow maize, millet and white sorghum as energy sources compared to commercial broiler diets (control). A completely randomized design was used where 160 guinea fowl keets were randomly assigned to four dietary treatments. Data were analyzed using Procedure General Linear Model in Statistical Analysis Software (version 9.0). Results showed that dietary treatment did not ($p > 0.05$) influence carcass characteristics of guinea fowl at the same age. However, carcass characteristics significantly ($p < 0.05$) increased with age. From 6 to 16 weeks of age carcass dressed weight of guinea fowl increased from 301.73 ± 9.49 g to 1003.65 ± 26.77 g; 288.18 ± 9.49 g to 952.58 ± 26.77 g; 305.00 ± 9.49 g to 976.55 ± 26.77 and 292.81 ± 9.49 g to 970.08 ± 26.77 g for control, maize, millet and *sorghum* diets, respectively. Carcass yield slightly increased from 69.93% ± 3.67% to 72.81% ± 2.67%; 73.85% ± 3.67% to 76.31% ± 2.67% and 70.55% ± 3.67% to 72.37% ± 2.67% for control, millet and *sorghum* diets, respectively. Carcass yield of guinea fowl on maize diet decreased with age (76.18 ± 3.67 to 71.68 ± 2.67). Other parameters including empty gizzard, heart, liver, drumstick, thigh, back and breast increased with guinea fowl age for all the dietary treatments. Maize, *sorghum* or millet diets can be used in guinea fowl diets without affecting carcass characteristics. Further studies on the acceptance of meat by consumers and cost-benefit analysis of the dietary treatments should be conducted to enable formulation of guinea fowl diets using local feed resources.

Keywords

Carcass Yield, Guinea Fowl, Keets, Local Feed Resources

1. Introduction

Guinea fowl production has gained momentum in various parts of the world [1] [2] though mostly under smallholder production [3]. Nevertheless, guinea fowl contributes substantially to the supply of animal protein in the form of meat and eggs [4] [5] [6]. Unlike chicken eggs, consumption of guinea fowl eggs is not popular, thus guinea fowl are raised mainly for meat which is served in restaurants around the world [7] [8]. The gamey flavour of guinea fowl meat with a higher protein content of approximately 28% compared to 20% of domestic fowl might be the factor that influences its preference and demand [9].

Guinea fowl have low input requirements with greater capacity to scavenge for feed and convert it to high quality meat [10]. Guinea fowl meat has a higher edible yield than chicken meat [11]. Musa *et al.* (2006) [12] noted that the success of poultry meat production is strongly related to improvements in growth and carcass yield, mainly by increasing breast proportion and reducing abdominal fat. The authors mentioned that the proportions of major carcass tissues (*i.e.*, breast, liver, heart, leg and abdominal fat) and their distribution throughout the carcass are important to carcass value. Manipulation of these traits depends on the combined genes and nutrition [12]. Therefore, guinea fowl production requires knowledge and understanding of their growth characteristics and patterns to allow for the design of optimum management practices [2].

The optimum slaughter age of guinea fowl is 16 weeks of age because of the subsequent decline in feed conversion ratio (FCR) [13] [14]. At this age, live weight of unimproved indigenous guinea fowl is approximately 1 kg [13] [15] compared to approximately 2 kg for improved strains [13]. According to Say (1987) [16] and Moreno *et al.* (2000) [17], guinea fowl meat contains higher protein content (23%) than beef (22.3%). In Botswana, Moreki *et al.* (2012) [18] obtained protein content of guinea fowl meat of 22.9% and 31.6% at 6 and 12 weeks of age, respectively. In another study, Mareko *et al.* (2008) [19] reported that guinea fowl meat protein content averages well above the typical mammalian muscle at 19%. Guinea fowl meat has low fat content (4%) compared to chicken (11%), lamb (25%) and pork (21%) [18]. This makes guinea fowl meat appealing to the health-conscious market. Therefore, the aim of this study was to evaluate the carcass characteristics of guinea fowl fed diets containing three cereal grains, *i.e.*, millet, white *sorghum* and yellow maize as energy sources compared to commercial broiler diets under intensive management system.

2. Materials and Methods

2.1. Experimental Site

The study was carried out at Botswana University of Agriculture and Natural Resources (BUAN) Guinea Fowl Rearing Unit, Sebele Content farm. The university is 24˚33'S, 24˚54'E and is located at an altitude of 994 m above sea level with an average annual rainfall of 538 mm and mean daily temperature of 30˚C.

2.2. Ethical Approval

This study was approved by the Animal Ethics Committee, Botswana University of Agriculture and Natural Resources.

2.3. Diet Formulation

Four experimental diets were formulated according to Botswana Standard for Guinea fowl (**Table 1**). The isonitrogenous and isocaloric experimental diets were formulated based on three local grown cereals; yellow maize, white *sorghum* and millet (**Tables 2-4**) with commercial broiler diets used as control (**Table 5**). Keets were fed the same commercial starter broiler diets from 1 to 20 days of age. The experimental diets were offered from 3 to 16 weeks of age.

Table 1. Nutrient composition of guinea fowl diets.

Nutrients	Starter	Grower		Breeder
		1	2	
Crude protein (%)	24 - 25	20	15	18
Metabolizable energy (MJ/kg)	12.13	12.13	11.30	12.13
Calcium (%)	1.2	1.00	0.80	3.0
Available phosphorus (%)	0.50	0.50	0.40	0.40
Sodium (%)	0.18	0.48	0.18	0.18
Arginine (%)	1.5	1.20	0.80	0.91
Lysine (%)	1.30	1.20	0.82	0.83
Methionine (%)	0.52	0.45	0.34	0.55
Methionine + cystine (%)	0.91	0.80	0.61	0.74
Tryptophan (%)	0.22	0.22	0.15	0.17
Histidine (%)	0.54	0.45	0.35	0.41
Leucine (%)	1.50	1.40	1.10	0.80
Isoleucine (%)	1.00	1.70	1.30	0.73
Phenyalanine (%)	1.00	0.93	0.74	0.74
Phenyalanine (%) + tyrosine (%)	1.50	1.4	1.1	1.00
Threonine (%)	0.93	0.81	0.62	0.71
Valine (%)	1.10	1.00	0.75	0.72
Vitamins (per kg of diet)				
Vitamin A (IU)	5000	4000	4000	5000
Vitamin D3 (IU)	2500	2000	2000	2500
Choline equivalents (mg)	1000	750	750	1000
Riboflavin (mg)	4.0	3.0	3.0	4.0
Pantothenic acid (mg)	12	9.0	9.0	12
Vitamin B12 (mg)	0.012	0.01	0.01	0.012
Folic acid (mg)	1.0	0.08	0.08	1.0
Biotin (mg)	0.25	0.20	0.20	0.25

Continued

Niacin (mg)	60	40	40	60
Vitamin K (mg)	2.0	1.5	1.5	2.0
Vitamin E (IU)	25	15	15	25
Thiamin (mg)	2.5	2.0	2.0	2.5
Pyridoxine (mg)	5.0	4.0	4.0	5.0
Trace minerals (per kg of diet)				
Manganese (mg)	70	55	55	70
Iron (mg)	80	70	70	80
Copper (mg)	10	8.0	8.0	10
Zinc (mg)	80	60	60	80
Selenium (mg)	0.30	0.2	0.2	0.3
Iodine (mg)	0.40	0.4	0.4	0.4

Source: Ensminger *et al.* (1990) [20]; Leeson & Summers (1997) cited in BOS 234:2006 [21].

Table 2. Composition of experimental diets fed to guinea fowl from 0 to 6 weeks of age.

	Dietary treatments		
	Yellow maize	***Sorghum***	**Millet**
Metabolisable Energy, MJ/Kg	12.13	12.13	12.13
Crude protein, %	24	24	24
Ingredient, %			
Yellow maize (10.6% CP)	46.27	-	-
Sorghum (10.6% CP)	-	48.99	-
Millet (14.0% CP)	-	-	55.93
Soybean meal (38% CP)	46.63	43.91	36.97
Fishmeal (60% CP)	3.0	3.0	3.0
Lucerne (16% CP)	2.0	2.0	2.0
Vitamin premix	1.5	1.5	1.5
Dicalcium Phosphate	0.35	0.35	0.35
Salt	0.25	0.25	0.25
Proximate analysis			
Dry matter, %	86.19	88.30	88.51
Moisture, %	13.81	11.70	11.49
Crude protein, %	24.76	22.98	23.75
Crude fibre, %	2.20	2.18	2.47
Crude fat, %	5.27	7.39	7.63
Ash, %	5.90	5.44	6.34
Nitrogen Free Extract, %	48.06	50.31	48.32
Metabolisable Energy, MJ/Kg	11.98	11.95	11.88

Table 3. Composition of experimental diets fed to guinea fowl from 7 to 12 weeks of age.

	Dietary treatments		
	Yellow maize	***Sorghum***	**Millet**
Metabolisable Energy MJ/Kg	12.13	12.13	12.13
Crude protein, %	20	20	20
Ingredient, %			
Yellow maize (10.6 CP)	61.00	-	-
Sorghum (10.6% CP)	-	64.42	-
Millet (14.0 CP)	-	-	72.58
Soybean meal (38% CP)	32.83	28.48	20.32
Fishmeal (60% CP)	3.0	3.0	3.0
Lucerne (16% CP)	2.0	2.0	2.0
Vitamin premix	1.5	1.5	1.5
Dicalcium Phosphate	0.35	0.35	0.35
Salt	0.25	0.25	0.25
Proximate analysis			
Dry matter, %	87.22	88.43	88.33
Moisture, %	12.78	11.57	11.67
Crude protein, %	20.48	19.73	19.17
Crude fibre, %	3.38	3.45	2.96
Crude fat, %	5.83	7.83	7.65
Ash, %	6.0	5.30	7.06
Nitrogen Free Extract, %	51.53	52.12	51.49
Metabolisable Energy, MJ/Kg	11.91	11.87	11.84

Table 4. Composition of experimental diets fed to guinea fowl from 13 to 16 weeks of age.

	Dietary treatments		
	Yellow maize	***Sorghum***	**Millet**
Metabolisable Energy, MJ/Kg	11.30	11.30	11.30
Crude protein, %	15	15	15
Ingredient, %			
Yellow maize (10.6% CP)	77.33	-	-
Sorghum (10.6% CP)	-	81.84	-
Millet (14.0% CP)	-	-	92.36
Soybean meal (38% CP)	15.57	11.06	0.54
Fishmeal (60% CP)	3.0	3.0	3.0
Lucerne (16% CP)	2.0	2.0	2.0
Vitamin premix	1.5	1.5	1.5

Continued

Dicalcium Phosphate	0.35	0.35	0.35
Salt	0.25	0.25	0.25
Proximate analysis			
Dry matter, %	88.42	88.14	88.03
Moisture, %	11.58	11.86	11.97
Crude protein, %	15.17	13.80	14.08
Crude fibre, %	3.47	3.83	3.83
Crude fat, %	5.85	7.90	7.21
Ash, %	573	5.42	6.41
Nitrogen Free Extract, %	58.20	57.19	56.50
Metabolisable Energy, MJ/Kg	11.20	10.99	10.96

Table 5. Nutrient composition of commercial broiler diets (mash) fed to guinea fowl from 0 to 16 weeks of age.

Ingredients	Starter	Grower	Finisher
Protein (%)	20	18	16
Moisture (%)	12	12	12
Fibre (%)	5.0	6.0	7.0
Calcium (%)	0.8	0.7	0.6
Fat (%)	2.5	2.5	2.5
Phosphorus (%)	0.6	0.6	0.5
Lysine (%)	1.2	1.0	0.9
Metabolisable Energy, MJ/Kg	12.0	12.2	12.6

2.4. Experimental Design

A total of 160 unsexed three weeks old keets were randomly allocated to 16 pens designed to meet the animal welfare standards for optimum production in guinea fowl. Each dietary treatment had four replicate pens as the experimental unit with 10 keets in a completely randomized design (CRD).

2.5. Animal Management

Keets were hatched at BUAN hatchery unit and raised in a closed house which provided both warmth and adequate ventilation. At 3 weeks of age, keets were transferred to growing pens where they were randomly assigned to 4 dietary treatment groups which comprised control diet and experimental diets consisting of yellow maize, white *sorghum* and millet as energy sources. Birds were housed in earth floor pens with perches. A drinker and a feeder were placed in each pen. Feed and water were provided *ad libitum* to all treatments.

2.6. Slaughter Procedure

At 6, 12 and 16 weeks of age, 3 birds from each replicate (12 birds from each dietary treatment) were randomly selected, weighed (final weight) and transported to BUAN slaughter facility for humane slaughter to assess carcass traits and internal organs. Feed and water were withdrawn 12 hours prior to slaughter to prevent digesta and faeces from contaminating carcasses. At the abattoir, the birds were slaughtered by cervical dislocation [22], bled by section of the jugular veins [23] and scalded in hot water at 65˚C - 70˚C for 3 minutes [24]. Thereafter, birds were de-feathered and eviscerated. Heads, necks and feet were then removed from carcasses.

2.7. Carcass Characteristics and Internal Organs

After slaughter, carcasses were immediately weighed to obtain the hot carcass mass. Following evisceration, internal organs (*i.e.*, gizzards, livers and hearts) were removed and weighed individually. Gizzards were emptied prior to weighing. The hot carcass weight of each bird was recorded and the dressing out percentage calculated. The slaughter weight and hot carcass weight were used to determine the dressing percentage of birds, expressed as carcass weight/final weight * 100 [25]. Thereafter, carcass cuts of the breast, thigh, back, wing and drumstick were removed and weighed separately. Parts yield (breast, thigh and drumstick) was calculated as the average parts and carcass weight using the formula, parts yield (%) = PY/CW * 100 [26]. Where, PY = parts yield and CW = carcass weight.

2.8. Statistical Analysis

Data on carcass characteristics and internal organs of guinea fowl meat were analysed using the GLM procedure of SAS. The PDIFF option of SAS (2010) [27] was used to perform pairwise comparisons of the least square means. The statistical model was as follows:

$$Y_{ij} = \mu + T_i + \varepsilon_{ij}$$

where: Y_{ij} = observation (carcass characteristics and internal organs), μ = population mean constant common to all observations, T_i = effect of diet and ε_{ij} = random error term, for all tests, the level of significance was set at $p < 0.05$.

3. Results

3.1. Carcass traits

Diets had no effect ($p > 0.05$) on the carcass traits of guinea fowl at 6, 12 and 16 weeks of age except on thigh weight at 6 weeks of age and back, wing and drumstick weights at 16 weeks of age (**Tables 6-8**). At 6 weeks of age, birds fed maize-based diet had lower ($p > 0.05$) thigh weights than the other dietary treatments which themselves did not differ significantly. Conversely, at 16 weeks of age, birds fed millet-based diet had lower ($p > 0.05$) wing weights than other dietary treatments which themselves did not differ significantly. Likewise, birds fed millet and maize-based diets recorded lower ($p > 0.05$) back and drumstick

Table 6. The effect of cereal-based diets on carcass traits and internal organs of guinea fowl at 6 weeks of age.

	Dietary treatments				SEM
	Control	Maize	Millet	*Sorghum*	
Carcass traits					
Live weight (g)	434.71	386.90	414.54	423.54	15.90
Carcass weight (g)	301.73	288.18	305.00	292.81	9.49
Carcass yield (%)	69.93	75.18	73.85	70.55	3.67
Breast weight (g)	70.49	70.79	73.01	73.80	3.93
Thigh weight (g)	44.71[a]	36.88[b]	44.54[a]	43.49[a]	1.61
Back weight (g)	33.04	33.21	34.08	37.08	1.52
Wings weight (g)	47.06	48.38	47.69	49.29	1.75
Drumstick weight (g)	34.55	33.86	35.18	37.05	1.20
Breast muscle yield (%)	16.31	18.36	17.78	17.35	0.94
Thigh yield (%)	10.38	9.66	10.77	10.48	0.57
Drumstick yield (%)	8.05	8.84	8.50	8.96	0.52
Internal organs					
Liver weight (g)	7.03	7.65	6.95	7.64	0.36
Heart weight (g)	2.73	2.97	2.90	3.15	0.18
Gizzard weight (g)	11.74	13.00	13.15	13.04	0.66

SEM = Standard Error of Means; [a,b,c]In a row, dietary treatment means with common superscripts do not differ ($p > 0.05$).

Table 7. The effect of cereal-based diets on carcass traits and internal organs of guinea fowl at 12 weeks of age.

	Dietary treatments				SEM
	Control	Maize	Millet	*Sorghum*	
Carcass traits					
Live weight (g)	960.93	902.76	918.10	933.90	81.41
Carcass weight (g)	690.55	659.17	681.00	674.12	60.13
Carcass yield (%)	71.81	74.03	74.19	72.13	1.76
Breast weight (g)	200.10	194.58	197.57	193.37	20.01
Thigh weight (g)	96.13	100.14	100.77	101.45	9.36
Back weight (g)	80.23	73.25	71.03	76.56	6.65
Wings weight (g)	97.63	94.85	91.05	95.26	7.10
Drumstick weight (g)	82.85	77.94	78.28	80.89	7.18
Breast muscle yield (%)	19.85	21.00	20.73	19.98	0.70
Thigh yield (%)	10.07	10.85	10.96	10.78	0.31
Drumstick yield (%)	8.53	8.78	8.54	8.73	0.24

Continued

Internal organs					
Liver weight (g)	11.01	11.50	10.85	11.48	0.66
Heart weight (g)	5.06	5.10	5.45	5.28	0.40
Gizzard weight (g)	18.01	19.50	20.85	20.92	1.26

SEM = Standard Error of Means; [a,b,c]In a row, dietary treatment means with common superscripts do not differ ($p > 0.05$).

Table 8. The effect of cereal-based diets on carcass traits and internal organs of guinea fowl at 16 weeks of age.

	Dietary treatments				SEM
	Control	Maize	Millet	*Sorghum*	
Carcass traits					
Live weight (g)	1384.83	1333.90	1287.95	1336.98	33.23
Carcass weight (g)	1003.65	952.58	976.55	970.08	26.77
Carcass yield (%)	72.81	71.68	76.31	72.73	2.67
Breast weight (g)	315.68	290.41	296.36	292.09	10.12
Thigh weight (g)	142.73	151.46	143.10	153.98	5.00
Back weight (g)	118.30^{a}	100.08^{b}	97.18^{b}	109.85^{ab}	5.03
Wings weight (g)	131.05^{a}	126.64^{a}	111.64^{b}	124.86^{a}	2.70
Drumstick weight (g)	122.60^{a}	110.33^{b}	110.03^{b}	120.03^{ab}	3.94
Breast muscle yield (%)	22.89	21.89	23.15	21.96	1.00
Thigh yield (%)	10.35	11.42	11.20	11.58	0.51
Drumstick yield (%)	8.89	8.33	8.60	9.01	0.39
Internal organs					
Liver weight (g)	14.06	14.75	13.48	14.04	0.50
Heart weight (g)	7.08	7.00	7.61	6.79	0.36
Gizzard weight (g)	20.86^{a}	$23.85.^{ac}$	28.91^{bc}	26.64^{c}	102

SEM = Standard Error of Means; [a,b,c]In a row, dietary treatment means with common superscripts do not differ ($p > 0.05$).

weights than those on control diet. Generally, the drumstick and back weights of birds fed cereal-based diets did not differ significantly from each other. Overall, the carcass traits increased ($p < 0.05$) with guinea fowl age for all the dietary treatments (Tables 9-14).

3.2. Internal Organs

Diets had no effect ($p > 0.05$) on the internal organs of guinea fowl at 6, 12 and 16 weeks of age except on gizzard weight at 16 weeks of age respectively (Tables 6-8). At 16 weeks of age, birds fed control diet had lower ($p > 0.05$) gizzard weight compared to those on millet and *sorghum*-based diets. Generally, the gizzard

Table 9. The effect of cereal based diets on carcass weight (g) of guinea fowl at 6, 12 and 16 weeks of age.

Week (days)	Dietary treatments			
	Control	Maize	Millet	*Sorghum*
6	301.73[a]	288.18[a]	305.00[a]	292.81[a]
12	766.28[b]	736.76[b]	761.45[b]	759.48[b]
16	1003.65[c]	952.58[c]	976.55[c]	970.08[c]
SEM	21.66	26.04	17.20	18.79

SEM = Standard Error of Means; [a,b,c]In a row, dietary treatments means with common superscripts do not differ ($p > 0.05$).

Table 10. The effect of cereal based diets on drumstick weight (g) of guinea fowl at 6, 12 and 16 weeks of age.

Week (days)	Dietary treatments			
	Control	Maize	Millet	*Sorghum*
6	34.55[a]	33.86[a]	35.18[a]	37.05[a]
12	91.41[b]	89.63[b]	89.63[b]	85.59[b]
16	122.60[c]	110.33[c]	110.03[c]	120.03[c]
SEM	2.18	3.19	2.17	3.19

SEM = Standard Error of Means; [a,b,c]In a row, dietary treatments means with common superscripts do not differ ($p > 0.05$).

Table 11. The effect of cereal based diets on thigh weight (g) of guinea fowl at 6, 12 and 16 weeks of age.

Weeks (days)	Dietary treatments			
	Control	Maize	Millet	*Sorghum*
6	44.71[a]	36.88[a]	44.54[a]	43.49[a]
12	100.94[b]	112.08[b]	114.66[b]	106.89[b]
16	142.73[c]	151.46[c]	143.10[c]	153.98[c]
SEM	4.62	3.88	3.22	3.63

SEM = Standard Error of Means; [a,b,c]In a row, dietary treatments means with common superscripts do not differ ($p > 0.05$).

Table 12. The effect of cereal based diets on back weight (g) of guinea fowl at 6, 12 and 16 weeks of age.

Week (days)	Dietary treatments			
	Control	Maize	Millet	*Sorghum*
6	33.04[a]	33.21[a]	34.08[a]	37.08[a]
12	89.34[b]	86.48[b]	81.85[b]	82.76[b]
16	118.30[c]	100.08[c]	97.18[c]	109.85[c]
SEM	3.74	3.37	2.60	4.48

SEM = Standard Error of Means; [a,b,c]In a row, dietary treatments means with common superscripts do not differ ($p > 0.05$).

Table 13. The effect of cereal based diets on breast weight (g) of guinea fowl at 6, 12 and 16 weeks of age.

Weeks (days)	Dietary treatments			
	Control	Maize	Millet	*Sorghum*
6	70.49[a]	70.79[a]	73.01[a]	73.80[a]
12	214.13[b]	222.53[b]	223.33[b]	214.21[b]
16	315.68[c]	290.41[c]	296.36[c]	292.09[c]
SEM	6.29	9.07	6.67	6.82

SEM = Standard Error of Means; [a,b,c]In a row, dietary treatments means with common superscripts do not differ (p > 0.05).

Table 14. The effect of cereal based diets on wing weight (g) of guinea fowl at 6, 12 and 16 weeks of age.

Weeks (days)	Dietary treatments			
	Control	Maize	Millet	*Sorghum*
6	47.06[a]	48.38[a]	47.69[a]	7.64[a]
12	114.76[b]	109.55[b]	111.64[b]	12.76[b]
16	131.05[c]	126.64[c]	113.83[c]	14.04[c]
SEM	1.91	2.33	17.20	0.51

SEM = Standard Error of Means; [a,b,c]In a row, dietary treatments means with common superscripts do not differ (p > 0.05).

weight for birds fed cereal-based diets were not significantly different from each other. Consistent with carcass traits, the internal organs increased ($p < 0.05$) with guinea fowl age for all dietary treatments (**Tables 15-17**).

4. Discussion

4.1. Carcass Traits

The success of poultry production is dependent on improved growth performance and carcass quality [12] [28] [29]. The present results show that diet significantly improved carcass traits of guinea fowl at same stage of growth except thigh weight at 6 weeks of age and wing and drumstick weights at 16 weeks of age. In agreement with this finding, Medugu *et al.* (2012) [30], Baurhoo *et al.* (2011) [31] and Masenya *et al.* (2021) [32] reported efficient use of cereal grains by poultry, which in turn resulted in superior carcass quality. Efficient utilization of feed has been shown to promote muscle development [32] [33], which is required by the growing market for cut-up poultry parts [34] [35]. Generally, birds fed millet-based diet had lower back, wing and drumstick weights at 16 weeks of age than other dietary treatments. This could be due to the intrinsic characteristics of pearl millet, particularly the high levels of phytic acid which has detrimental effect on protein utilization and bone mineralization. Pearl millet contains 354 - 796 mg/g^{-1} of phytic acid (Abdalla *et al.*, 1998) [36] which is believed

Table 15. The effect of cereal based diets on liver weight (g) of guinea fowl at 6, 12 and 16 weeks of age.

Weeks (days)	Dietary treatments			
	Control	Maize	Millet	*Sorghum*
6	7.03[a]	7.65[a]	6.95[a]	7.64[a]
12	11.95[b]	12.11[b]	12.13[b]	12.76[b]
16	14.06[c]	14.75[c]	13.48[c]	14.04[c]
SEM	0.50	0.44	0.53	0.51

SEM= Standard Error of Means; [a,b,c]In a row, dietary treatments means with common superscripts do not differ (p > 0.05).

Table 16. The effect of cereal based diets on heart weight (g) of guinea fowl at 6, 12 and 16 weeks of age.

Weeks	Dietary treatments			
	Control	Maize	Millet	*Sorghum*
6	2.73[a]	2.98[a]	2.90[a]	3.15[a]
12	5.38[b]	5.33[b]	5.84[b]	5.91[b]
16	7.08[c]	7.00[c]	7.61[c]	6.79[c]
SEM	0.32	0.25	0.33	0.26

SEM = Standard Error Means; [a,b,c]in a row, dietary treatment means with common superscripts do not differ (p > 0.05).

Table 17. The effect of cereal based diets on gizzard weight (g) of guinea fowl at 6, 12 and 16 weeks of age.

Weeks	Dietary treatments			
	Control	Maize	Millet	*Sorghum*
6	11.74[a]	13.00[a]	13.15[a]	13.04[a]
12	20.86[b]	21.64[b]	20.50[b]	23.08[b]
16	21.43[c]	23.85[c]	28.91[c]	26.64[c]
SEM	1.29	0.98	0.94	0.95

SEM = Standard Error of Means; [a,b,c]In a row, dietary treatments means with common superscripts do not differ (p > 0.05).

to affect the digestion of protein and mineral bioavailability in diets [37] [38]. This eventually could have affected the availability of amino acids and minerals (especially phosphorus) needed for muscle development resulting in lower carcass traits.

The weight of carcass traits in this study increased with guinea fowl age for all the dietary treatments. This finding is consistent with Kokoszyński *et al.* (2011) [39] who obtained a steady increase of carcass dressed weight of 866 to 947 g and 890 to 973 g for male and female guinea fowl, respectively from 13 to 16 weeks of age. For Nsoso *et al.* (2006) [40], body weight increase demonstrates growth and development in farm animals. The present study recorded higher carcass parts weights than those reported in previous studies at 16 weeks of age. Nsoso *et al.* (2003) [41] [42] reported lower drumstick and thigh weights of 100 and 140 g at 16 weeks of age. Similarly, Saina (2005) [42] reported 105.6 ± 11.1 g and 131.7 ± 15.5 g during the same period. On the other hand, Ogah (2011) [43] obtained lower breast weight of 267.23 ± 1.69 g than those found in the present study at 16 weeks of age. This differences in carcass parts weights could be due to variation in dietary treatments and guinea fowl strains. The present study used pearl and lavender strains while Nsoso *et al.* (2003) [41] used the progenies of wild and domesticated indigenous guinea fowl (the pearl) strains. Saina (2005) [42] reported that indigenous guinea fowl strains have lower performance than improved strains.

The guinea fowl carcass yield (dressing percentage) obtained in the present study at 12 weeks of age was comparable to Fuentes *et al.* (1998) [44] values of 75.13% and 75.74% for male and female guinea fowl, respectively. On the contrary, Seabo *et al.* (2011) [45] reported higher carcass yield values of 87.5%, 87.6% and 87.5% in guinea fowl on 14% CP, 16% CP and 18% CP diets, respectively during the same period. The difference in carcass yield between the three studies could be due to variations in sources of protein for dietary treatments. In the present study and that of Fuentes *et al.* (1998) [44], soybean meal was used as a protein source in dietary treatments, whereas Seabo *et al.* (2011) [45] used sunflower cake as a protein source. Araújo *et al.* (2011) [46] contended that despite its high fibre content (14%) and deficient lysine (0.5%) compared to soybean meal, sunflower cake is relatively rich in sulphur amino acids (methionine and cysteine). Sulphur amino acids are essential for optimum muscle accretion [47].

Nevertheless, Mareko *et al.* (2006) [25] reported a higher carcass yield of 94.17% at 12 weeks of age than the values obtained in the current study of 71.81% ± 1.76%, 74.03% ± 1.76%, 74.19% ± 1.76% and 72.13% ± 1.76% for control, maize, millet and *sorghum* diets, respectively during the same period. The variation in carcass yield values between the two studies could be due to difference in dietary treatments for guinea fowl stage of growth. The present study fed commercial broiler diet (control) and formulated guinea fowl diets consisting of cereal-based diets as starter, grower and finisher diets while in the study by Mareko *et al.* (2006) [25] guinea fowl were fed only broiler grower diet. In agreement with the present study, Saina (2005) obtained carcass yield value of 71.6% in guinea fowl at 16 weeks of age. However, Kokoszyński *et al.* (2011) [39] reported lower carcass yield values of 70.1% and 70.7% in male and female guinea fowl, respectively at 16 weeks of age. According to Mareko *et al.* (2006) [25], carcass dressing percentage is influenced by the stage of maturity, degree of finish, breed and intestinal contents (offal).

4.2. Internal Organs

Generally, the increase in liver and heart sizes is indicative of the presence of toxic substances in diets [48] [49]. In this regard, the present study shows that cereal-based diets did not affect liver and heart sizes indicating the absence of toxic substances in these diets. Similarly, diets did not affect gizzard weight but there was a tendency of birds fed cereal based diets to have slightly higher gizzard weights. These results are consistent with findings by Rama Rao *et al.* (2003) [50] and Ibitoye *et al.* (2012) [51] who found no significant difference in gizzard and liver weights in broilers fed cereal based diets. On the contrary, Masenya *et al.* (2021) [32] reported lower liver and gizzard weights in Jumbo quails fed *sorghum*-based diets. The observed increase in gizzard weight in birds fed cereal based diet could be attributable to the significant crude fibre values that range from 2.7 to 4.9, 1.65 to 7.94 and 13% in maize, *sorghum* and millet grains, respectively [38] [52] [53]. The size of the gizzard is determined by the amount of work required by the muscular walls of the organ to grind feed particles (Obun *et al.*, 2008) [54], which is strongly stimulated by fibre structures [55].

The current study showed an increase in giblets weights (liver, heart and gizzard) with advancing age of guinea fowl. This could have resulted from the development of body organs which occurs as birds advance in age to conform to the general growth pattern [56]. Equally, diet and its components affect structural, physiological and histological changes of internal organs [39] [57] [58] [59]. In this study, giblets weights were observed to be higher than those recorded in previous studies. The current study recorded an increase in heart, liver and empty gizzard weights, respectively at 12 weeks of age whereas Seabo *et al.* (2011) [45] reported lower heart, liver and empty gizzard weight values which ranged from 3.85 - 3.89 g, 22.13 - 22.21 g and 26.48 - 27.50 g, respectively during the same period. The difference in giblet weights between the two studies could be attributed to varying protein levels in dietary treatments. In the present study, the crude protein levels were 20%, 18% and 16% for control diet, starter, grower and finisher diets, respectively and 24%, 20% and 15% for experimental guinea fowl diets. On the contrary, Seabo *et al.* (2011) [45] used the crude protein levels of 18%, 16% and 14% for starter, grower and finisher diets, respectively. In accordance with this study, Hosseini-Vashan *et al.* (2010) [60] reported an increase in liver weight of broiler chickens with increased crude protein levels.

5. Conclusion

Generally, dietary treatment had no influence on guinea fowl carcass characteristics and internal organs at 6, 12 and 16 weeks of age. However, carcass characteristics and internal organs increased with guinea fowl age for all the dietary treatments. These results suggest that yellow maize, white *sorghum* or pearl millet diets can be used in guinea fowl diets without affecting the carcass characteristics and internal organs. Further research on meat characteristics and acceptance by consumers, as well as, cost-benefit analysis of the dietary treatments should be carried out to evaluate the effect of formulating guinea fowl diets using locally available cereal grains.

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Conflicts of Interest

The authors declare no conflict of interest.

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