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Full Length Research

PERFORMANCE OF SOME BROILER STRAINS FED VARYING ENERGY LEVELS IN COLD SEASON OF SEMI-ARID SOKOTO, NIGERIA

Sa'adu A.[1], Bashar Y. A.[1], Abubakar A.[1], Abbas A. Y.[2], Lawal N.[3], Mani A. I.[1], and Ribah, M. I.[4]*

[1]Department of Animal Science, Faculty of Agriculture, Usmanu Danfodiyo University, Sokoto, Nigeria.

[2]Department of Biochemistry, Faculty of Science, Usmanu Danfodiyo University, Sokoto, Nigeria.

[3]Department of Microbiology, Faculty of Veterinary Medicine, Usmanu Danfodiyo University, Sokoto, Nigeria.

[4]Department of Animal Science, Faculty of Agriculture, Kebbi State University of Science and Technology, Aliero, Nigeria.

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Three broiler strains were placed on three different dietary energy and crude protein levels of 2900 KCal/Kg (ME) - 22% CP, 3100 KCal/Kg (ME) - 23% CP, and 3300 KCal/Kg (ME) - 24% CP representing low, medium and high energy levels, respectively, at starter phase. At the finisher phase, they were fed 2800 KCal/Kg (ME) - 19% CP, 3000 KCal/Kg (ME) - 20% CP and 3200 KCal/Kg (ME) - 21% CP in order to determine their productive performance in cold weather of semi-arid environment. A total of 675 birds were used in a completely randomized design (CRD) comprising 225 birds each of *Arbor-acre, Hubbard* and *Marshall* Strains serving as treatments with each group replicated five times so that each replicate had 15 birds. Each strain group was fed three different dietary energy levels at both starter and finisher phases for 56 days. Feed and water intake, weight gain, feed conversion ratio, and mortality were recorded. Cost/kg gain was determined at the end of both starter and finisher phases. Data recorded subjected to analysis of variance (ANOVA) and least significant difference (LSD) was used to compare the means. Results obtained in cold season revealed that there was no significant difference (P>0.05) in terms of average daily gain, feed intake, mortality and cost/kg gain across all the strain groups, but *Arbor-acre* and *Hubbard* strains had significantly (P<0.05) lower mortality than *Marshall* strain. Low energy diet had significant effect (P<0.05) on cost/kg gain, feed conversion ratio and highest weight gain compared to medium and high energy diets, at starter phase. At the finisher phase however, *Arbor-acre* strain had significantly lowest (P<0.05) feed conversion ratio and cost/kg gain and significantly (P<0.05) higher daily weight gain than other strains. Birds on low energy diet had significantly lowest (P<0.05) cost/kg gain and mortality and significantly highest (P<0.05) daily gain than birds on both medium and high energy diets. The study concluded that *Arbor-acre* strain could perform better owing to the lower mortality, cost/kg gain and higher average daily gain compared to other strains. It should therefore be raised and fed low energy diet in the cold season of semi-arid environment.

Keywords: Performance, Broiler Strains, Energy Levels, Cold Season, Semi-Arid.

INTRODUCTION

Broiler birds have the potential of providing quality protein to the populace owing to its short generation interval, thereby creating source of employment, revenue generation and quicker return of investment. Yet, in cold season of semi-arid Sokoto Nigeria, low ambient temperature experienced in this period modifies energy requirements of the birds as a result of excess calories required for thermoregulation. Similarly, according to Udeh et al. (2011) some strains of broiler perform better in cold than in hot environment.

The cold season of Sokoto semi-arid Nigeria extends from late October through January and it is characterized by low ambient temperatures (Sokoto Environmental protection program, metrological data, Unpublished. 1996; Abdulrahim et al., 2013). This low ambient temperature however, demands for changes in the energy content of the diet (Oluyemi and Roberts 2000; Razuki, 2002). Similarly, broiler strains commonly supplied to the farmers in semi-arid Sokoto include *Arbor-acre*, *Hubbard* and *Marshall* which were developed in Asia and Europe, hatched and distributed by some companies in south western Nigeria, however, these differences in the environments and strains resulted in having inconsistent performance resulting from using a particular strain of broiler across different seasons of semi-arid Sokoto.

Furthermore, nutrient requirements of broiler birds depend on a number of factors which include strain of the bird, age and environment in which the birds are reared. Hence, identifying the strain that performs better in cold season of semi-arid Sokoto when given certain energy level significantly improve broiler production in the region, and probably reduce cost of feeding as energy sources among feeding stuffs of broilers are most expensive.

MATERIALS AND METHODS

Study Area

The experiment was conducted at the Poultry Production and Research Unit of the Department of Animal Science, Usmanu Danfodiyo University, Sokoto, Sokoto State. Sokoto is located between latitudes 12^{o} and 13^{o} 05'N and between longitudes 4^{0}8 and 6^{0}4 E in the northern part of Nigeria and at an altitude of 350m above sea level (Mamman et al., 2000). The State falls within the Sudan savannah vegetation zone, with alternating wet and dry seasons. A short, cool, dry period (Harmattan) lasts between late October and late February (Malami et al., 2001).

EXPERIMENTAL DESIGN

A total of 675 broiler birds were used in each of the trials, 225 birds each of *Hubbard, Arbor acre*, and *Marshall* Strains in a completely randomized design (CRD). Each of these strains was divided into three different energy groups of five replicates and each replicate contained fifteen birds. The three different energy groups for starter phase were 2900 KCal/Kg (ME) - 22% CP, 3100 KCal/Kg (ME) - 23% CP, and 3300 KCal/Kg (ME) - 24% CP, respectively. For the finisher group energy and protein levels were 2800 KCal/Kg (ME) 19% CP, 3000 KCal/Kg (ME) - 20% CP and 3200 KCal/Kg (ME) -21% CP, respectively as indicated in Table 1 and Table 2, respectively.

Sources of Experimental Birds

The birds used for the experiment were sourced from three commercial hatcheries from Oyo State, Nigeria. The strains used were *Hubbard, Marshall* and *Arbo acre* broiler strains. The birds were purchased from these hatcheries at the same time so that each strain was obtained in the same day.

Birds and their management

Experimental birds were kept for three days after transport to take care of stress due to transportation. During the three days, they were administered appropriate anti-stress drugs, later weighed and allotted to their replicate treatment groups. Each strain group (treatment) was replicated five times. Routine vaccinations were administered; antibiotics and coccidiostats were also administered according to the recommendations of Oluyemi and Roberts (2000). The birds were housed on a deep litter with open sided walls covered with polythene bags to conserve heat at early age and additional heat inform of burning coal pot was provided to increase room temperature. The house and pens were cleaned, washed fumigated and disinfected prior to

*Corresponding Authors' Contacts ✉:+2347036333707, ibrahim.ribah73@gmail.com

Table 1. Gross and calculated chemical composition of diets to be fed at the starter phase.

Ingredients (%)	Diet 1	Diet 2	Diet 3
Maize	50.00	54.50	50.00
Groundnut cake	14.50	32.00	30.00
Soya bean meal	20.00	4.50	7.50
Wheat Offal	4.00	2.00	-
Maize Bran	5.00	-	-
Blood Meal	1.50	2.00	3.50
Lime Stone	2.00	2.00	2.00
Bone Meal	1.80	1.80	1.80
Premix**	0.25	0.25	0.25
Methionine	0.30	0.30	0.30
Lysine	0.30	0.30	0.30
Salt	0.30	0.30	0.30
Oil	-	-	4.00
Total	**100**	**100**	**100**
Calculated Analysis			
M.E.Kcal/kg	2,911	3,070	3,282
C.P.(%)	22.00	23.00	24.00
P(av)(%)	0.45	0.39	0.40
Ca(%)	1.27	1.27	1.28
EE	3.73	4.63	4.12
C.F	3.98	3.17	3.02
Methionine	0.60	0.60	0.60
Lysine	1.36	1.22	1.35

***Vitamin A 30000000 i.u, Vitamin D3 6000000 i.u, Vitamin E 30000 i.u, Vitamin K 2000 mg, Vitamin B2 30000mg, Vitamin C 30 g, Niacin 40000 mg, Panthothenic acid 12000 mg, Vitamin B6 1500 mg, Vitamin B12 10000 mg, Folic acid 1000 mg, Bioton 400 mg, Choline chloride 300000 mg, Cobalt 200 mg, Copper 1200 mg, Iodine 20000 mg, Iron 40000 mg, Manganese 100000 mg, Selenium 150 mg, Zinc 30 mg, Antioxidant 1250 mg
**M.E= Metabolisable energy, C.P=Crude protein, P(av)=Available phosphorous, Ca=calcium, C.F= crude fiber, and EE = Ether extract

the arrival of the birds. Wood shavings were used as litter material.

Period and Duration of the Experiments

The experiment was carried out in the months of November to January because they are characterized low ambient temperature and cool dry spell for the period of 56 days (8 weeks) for both starter and finisher phases from 20th November, 2015 to 15th January, 2016. At the end of starter phase the replicates were combined together and then re-allotted for finisher phase depending on the number of birds that survived to the finisher phase

Table 2. Gross and calculated chemical composition of diets to be fed at the finisher phase.

Ingredients (%)	Diet 1	Diet 2	Diet 3
Maize	45.50	57.10	52.00
Groundnut cake	16.00	22.00	28.00
Soya bean meal	11.50	7.00	7.00
Wheat Offal	10.00	8.00	5.00
Maize Bran	12.00	-	-
Blood Meal	-	1.00	-
Lime Stone	2.00	2.00	2.00
Bone Meal	2.00	1.90	1.90
Premix**	0.25	0.25	0.25
Methionine	0.21	0.20	0.25
Lysine	0.21	0.20	0.25
Salt	0.30	0.30	0.30
Oil	-	-	3.00
Total	**100**	**100**	**100**
Calculated Analysis			
M.E.Kcal/kg	2,827	2,977	3,178
C.P.(%)	19.00	20.00	21.00
P(av)(%)	0.44	0.41	0.41
Ca(%)	1.31	1.29	1.29
EE	3.53	4.15	4.18
C.F	4.75	3.39	3.32
Methionine	0.48	0.47	0.53
Lysine	1.02	1.03	1.06

***Vitamin A 30000000 i.u, Vitamin D3 6000000 i.u, Vitamin E 30000 i.u, Vitamin K 2000 mg, Vitamin B2 30000mg, Vitamin C 30 g, Niacin 40000 mg, Panthothenic acid 12000 mg, Vitamin B6 1500 mg, Vitamin B12 10000 mg, Folic acid 1000 mg, Bioton 400 mg, Choline chloride 300000 mg, Cobalt 200 mg, Copper 1200 mg, Iodine 20000 mg, Iron 40000 mg, Manganese 100000 mg, Selenium 150 mg, Zinc 30 mg, Antioxidant 1250 mg

**M.E= Metabolisable energy, C.P=Crude protein, P(av)=Available phosphorous, Ca=calcium, C.F= crude fiber, and EE = Ether extract

after which the experiment was terminated.

DATA COLLECTION

Feed intake was recorded on daily basis by subtracting remnants from quantity offered the previous day. Body weight gain was recorded weekly by weighing the birds and determining increase or loss of weight from which average daily gain was determined. Record of feed intake and weight gain were used to compute the feed

Table 3. Main effects of strain, energy and interactions on growth and performance parameters of different broiler strains at starter phase in cold season of semi-arid Sokoto.

Factor	ADG (g/b)	Feed intake (g/b/day)	FCR	Water intake (mls/b/day)	Mortalit y (%)	Cost/kg gain(~~N~~)
Strain						
Arbor-acre	14.26	44.49	3.158	68.59	6.67[b]	304.11
Hubbard	14.43	43.30	3.03	71.12	8.89[b]	292.37
Marshall	14.86	47.70	3.22	73.75	15.11[a]	310.55
SEM	**0.58**	**1.30**	**0.12**	**2.756**	**2.32**	**13.29**
Energy						
Low energy	16.80[a]	48.15[a]	2.89[b]	82.34[a]	11.11	265.47[c]
Medium energy	12.79[c]	42.03[b]	3.31[a]	62.17[c]	12.00	301.44[b]
High energy	13.96[b]	44.31[b]	3.20[a]	68.95[b]	7.56	340.12[a]
SEM	0.39	2.60	0.11	1.70	2.47	
Strain X Energy	NS	NS	NS	NS	*	NS

Means with different superscript across the column are statistically significant at (P<0.05)
ADG= Average daily gain
FCR= Feed conversion ratio

conversion ratio for each replicate. This was done for both starter and finisher stages of the study.

Data Analysis

Data obtained from feed intake, water intake, weight gain, feed conversion ratio, efficiency, and carcass evaluation was subjected to Analysis of Variance (ANOVA) using Stat View Analytical computer package version 5 (SAS, 1998). Regression model was used to determine the relationship between the variables, which are Temperature and relative humidity with feed intake, water intake and mortality. Least significant difference (LSD) was used to compare means while mortality was calculated in percentage.

RESULTS

Table 3 shows the main effects of strains, energy levels and their interactions on growth performance of three broiler strains at starter phase of cold season in semi-arid Sokoto. Non-significant difference (P>0.05) was observed in terms of all the performance parameters (Average daily gain, feed intake, feed conversion ratio, water intake and cost/ kg gain) across all the three strains (*Arbor-acre*, *Hubbard* and *Marshall*) strains in cold season of semi-arid Sokoto except for mortality where *Marshall* strain was observed to have significantly (P<0.05) higher mortality of 15.11% as compared to both *Arbor-acre* and *Hubbard* strains which had a mortality of 6.67 and 8.89%, respectively.

On the contrary, irrespective of strain significant differences (P<0.05) were observed in terms of all the performance parameters (Average daily gain, feed intake, feed conversion ratio water intake and cost/kg gain) except for mortality. It was observed that; the birds that consumed low energy diet had significantly (P<0.05) highest average daily gain of 16.8 gram/bird as compared to those that consumed medium and high energy diets. Similarly, those that consumed low energy diet irrespective of the strain were observed to have significantly higher average daily gain of 13.96 gram/bird/day as compared to those that consumed medium energy diet which had an average daily gain of 12.79 gram/bird. However, there was no significant difference (P>0.05) between the feed intake of birds fed both high and medium energy diets. Significant difference (P<0.05) existed between birds that consumed low energy diet, which had an average daily feed intake of 48.15 gram/bird while those that consumed medium and high energy diets that had an average daily intake of 42.03 and 44.31 gram/bird, respectively.

Furthermore, significant difference (P<0.05) was observed with regards to feed conversion ratio of broiler birds fed different energy levels at starter phase of cold season. It was observed that broilers that consumed low energy diet had a significantly (P<0.05) lower and a better feed conversion ratio of 2.89 as compared to those that consumed medium and high energy diets which had a feed conversion ratio of 3.31 and 3.20, respectively. Similarly the birds that consumed low energy diet were observed to have significantly (P<0.05) highest water intake of 82.3 millilitres/bird/day as compared to those that consumed low and medium energy diets which had an average daily water intake of 62.17 and 68.95 millilitres/bird/day, respectively. Energy levels did not affect the mortality of the birds at starter phase of cold season, therefore, non-significant difference (P>0.05) was observed across all the three energy levels with respect to mortality. However, Significant difference (P>0.05) was observed across energy levels with regards to cost/kg gain where the birds that consumed high energy diet had the highest cost/kg gain of N340.12 while those that consumed medium energy diet had significantly (P<0.05) lower, cost/kg gain of N301.40 as compared to those that consumed high energy diet, but those that consumed low energy diet were observed to have significantly (P<0.05) lowest and most economical cost/kg gain of N265.47 as compared to those that consumed both medium and high energy diet. Significant interaction (P<0.05) between strains and energy levels at starter phase of cold season was observed only with respect to mortality, while there was no significant interaction (P>0.05) with regards to other parameters.

Table 4 shows the main effect of strain, energy and their interactions on growth and performance parameters of different broiler strains at finisher phase in cold season of semi-arid Sokoto. Significant differences (P<0.05) were observed in terms of average daily gain, feed conversion ratio, and cost/kg gain due to main effect of strain at finisher phase of cold season, but no-significant difference (P>0.05) was observed in terms of feed intake, water intake and mortality. *Arbor-acre* strain was observed to have significantly (P<0.05) higher value of average daily gain of 39.17 gram/bird than *Marshall* strain which had an average daily gain of 34.68 gram/bird but there was no significant difference (P>0.05) between *Hubbard* and either *Arbor-acre* or *Marshall* strains. Similarly, *Marshall* strain was observed to have significantly (P<0.05) higher value of feed conversion ratio (3.39) than *Arbor-acre* strain which had a value of 3.03, but there was no significant difference (P>0.05) between *Hubbard* strain that had a value of 3.22 and either *Arbor-acre* or *Marshall* strain. Furthermore, *Marshall* Strain was observed to have significantly (P<0.05) higher of cost/kg gain of N341.96 than *Arbor-acre* strain which had a value of N303.60, but there was no significant difference (P>0.05) between *Hubbard* strain that had a cost/kg gain of N323.00 and either *Arbor-acre* or *Marshall* strain.

Significant differences (P<0.05) were observed in terms of average daily gain, feed intake water intake, mortality and cost/kg gain. But non-significant difference (P>0.05) was observed only in feed conversion ratio, of broiler birds fed different dietary energy levels at finisher phase in cold season. Irrespective of the strain the birds that consumed low energy diet had significantly (P<0.05) higher average daily gain of 39.88g/b than those that consumed medium and high energy diets which had an average daily gain of 35.58 and 35.35 gram/bird, respectively. Similarly, it was observed that the birds that consumed low energy diet had significantly (P<0.05) higher feed intake of 125.81 gram/bird/day than those that consumed medium and high energy diets which had an average daily feed intake of 107.17 and 115.60 gram/bird, respectively. Significant differences (P<0.05) also existed between broilers that consumed medium and high energy diets, the birds that consumed low energy diet had significantly (P<0.05) higher water intake of 255.41 milliliters/bird/day as compared to those that consumed medium and high energy diets which had an average daily water intakes of 214.59 and 226.07 milliliters/bird/day, respectively. But the birds that consumed high and medium energy diets were observed to have significantly (P<0.05) higher mortality of 15.95 and 15.86%, respectively, compared to those that consumed low energy diet which had percentage mortality of 7.68. However, those that consumed high energy diet were found to have significantly (P<0.05) higher cost/kg gain of ₦336.97 above those that consumed medium and low energy diets which had cost/kg gain of 305.07 and ₦296.53 respectively but there was no

Table 4. Main effects of strain, dietary energy level and their interactions on performance parameters of different broiler strains at finisher phase in cold season of semi-arid Sokoto.

Factor	ADG (g/b)	Feed intake (g/b/day)	FCR	Water intake (mls/b/day)	Mortality (%)	Cost/kg gain(₦)
Strain						
Arbor-acre	39.17[a]	118.23	3.03[b]	223.96	10.31	303.60[b]
Hubbard	35.96[ab]	114.65	3.22[ab]	228.63	12.49	323.0[ab]
Marshall	34.68[b]	115.70	3.39[a]	243.47	16.70	341.96[a]
SEM	**1.25**	**3.31**	**0.23**	**6.98**	**2.65**	**12.63**
Energy						
Low energy	39.88[a]	125.81[a]	3.19	255.41[a]	7.68[b]	296.53[b]
Medium energy	35.58[b]	107.17[c]	3.11	214.59[b]	15.86[a]	305.07[b]
High energy	35.35[b]	115.60[b]	3.34	226.07[b]	15.95[a]	366.97[a]
SEM	**1.19**	**2.64**	**0.10**	**5.85**	**2.53**	**10.62**
Strain X **Energy**	NS	NS	NS	NS	NS	NS

Means with different superscript across the column are statistically significant at (P<0.05)
ADG=Average daily gain
FCR= Feed conversion ratio

significant difference (P>0.05) in the cost/kg gain between birds that consumed medium or low energy diet.

Non-significant interaction (P>0.05) was observed between main effect of strain and energy in terms of all the production parameters at this phase of the experiment.

DISCUSSION

Main Effects of Strains, Energy Levels and Interaction on Growth Performance Parameter of Different Broiler Strains at Starter Phrase In Cold Season Of Semi-Arid Sokoto

The non-significant difference seen in terms of all performance parameters across all the three strains in cold season of semi-arid Sokoto except for mortality is in line with the findings of Kumar et al. (1976); Heregrouth, (1988); Turkoglus and Akin (1991) and Soares et al. (1992) have independently reported non-significant difference in the feed conversion ratio of different broiler strains tested in their different experiments. Similarly, Ahsanul et al. (2003) also reported significant difference in the percentage mortality of *Hubbard*, *Arbor-acre* and *Starbo* broiler strains, however the percentage mortality they reported for *Arbor-acre* strain (6.66%) was almost the same with that obtained in the current study (6.67%), while the 10% mortality they reported for *Hubbard* is close to 8.89% mortality reported for the same *Arbor acre* in the present study, which is equally in line with the current studies. Furthermore, Javid-iqval et al. (2012) reported significant difference in the mortality rates and cost/kg gain of few broiler strains; *Hubbard*, *Arbor-acre*, *Ross 308* and *Hybro,* which is in agreement with the findings of this study. The current findings however, disagreed with that of Zahid and Hussain (2002) that reported significant difference in the live weight of six broiler strains namely; *ISA*, *Ross*, *Indian River*, *Arbor-acre*, *Lohman* and *Hubbard* strains at both third and fourth weeks of age. However, this difference could be due to the fact that, more number of strains are used in their researches and also differences in the environment in which the two separate experiments were conducted. Similarly, Indarish and Pym (2009) reported significant difference in feed intake and feed conversion ratio of three broiler strains; *Cobb*, *Ingham* and *Steggels* which also contradicts the current research but these differences may be due to the fact that; they are entirely different strains in two experiments, environment and nature of the experiment could also be another reason for the differences. The significant differences observed at this phase of the experiment under main effect of energy in terms of average daily gain, feed intake, feed conversion ratio water intake and cost/kg gain are in agreement with the results of Tomas et al. (1988) also reported significant difference on performance parameters of broiler birds fed different energy and protein levels in their different experiments. Similarly, Mukhtar et al. (2007) suggested that an increase level of dietary protein in broiler diets improves their growth and performance characteristics which are equally in line with the findings of this study. Similarly the result of the current research is in line with that of Achi et al. (2007) that showed significant difference in most of the performance parameter of broiler birds fed different dietary levels of energy and protein. Indarish and Pym (2009) equally reported significant effect of protein levels on the performance of broiler birds which also agrees with the findings of this study. But Kim et al. (1996) reported non-significant difference (P>0.05) in the feed conversion ratio and weight gain of broiler birds fed different protein levels which contradicts the findings of the current study. Similarly, Gu et al. (2008) reported non-significant difference in average daily feed intake, average daily gain and feed conversion ratio of broiler birds fed different protein levels (18.7, 20.0 and 21.3%) which also disagrees with the findings of this research, Hassan et al. (2011) reported non-significant difference in the feed intake of broiler birds fed different protein levels, which disagrees with the findings of the current study.

Significant interaction between strains and energy levels at starter phase of cold season observed only with respect to mortality and non-significant interaction (P>0.05) with regards average daily gain, feed intake, feed conversion ratio, water intake and cost/kg gain disagrees with that of Syed el al. (1998) that reported significant interaction (P<0.05) between strains of broiler and seasons in terms of feed conversion ratio and at the same time agrees with their findings in terms of mortality. It equally disagrees with the findings of Namakparrar et al. (2014) that stated significant interaction (P<0.05) between strain and sex on the feed conversion ratio and weight gain of three broiler strains. Similarly, Attia et al. (2015) reported a significant interaction between two strains of broilers placed on four different feeding regiments under hot season of Saudi Arabia.

Main Effects of Strains, Energy and Interactions on Performance Parameters of Different Broiler Strains at Finisher Phase in Cold Season of Semi-Arid Sokoto

Under main effect of strain at finisher phase of cold season, significant differences observed in terms of average daily gain, feed conversion ratio, and cost/kg gain and non-significant difference recorded with regards to feed intake, water intake and mortality, were in line with results obtained by Indarish and Pym (2009) which reported significant difference in the feed conversion ratio and body weight gain of different broiler strains placed on different protein levels. Similarly, Amao et al. (2011) observed significant difference in the average daily gain and feed conversion ratio of three broiler strains namely *Ross*, *Anak* and *Marshall* which is equally in line with the outcome of this study. In the same vein, Idahor et al. (2013) also reported non-significant difference (P>0.05) in the mortality and feed intake of four broiler strains (*Hubbard*, *Kucbor*, *Arbor-acre* and *Powl*) placed at different feeding regiments which is in line with the findings of this study. However, Ansari (1985) reported non-significant differences (P>0.05) in the feed conversion ratio of *Piltch*, *Hypeco* and *Indian river* broiler strains which is contradictory to the findings of this study. These differences could be the result of different genetic make-up of the strains involved the environment in which the birds were raised and also the genetic improvement that might have been achieved from the time the research was conducted to the present study. Similarly, Chrismas (1993) and Ravindian et al. (1999) reported significant difference in the feed consumption of various broiler Strains in their separate researches, which further contradicts the findings of the current research. These differences could also be due to differences in the environment and strains involved. In the same vein, Zahid and Hussain (2002) reported non-significant differences in the weight gain of six commercial broiler strains from 35 days of age onward which also contradicts the outcome of the present study and these differences could be purely attributed to differences in the environment. Hassan et al. (2011) reported significant differences in the feed consumption of three broiler strains raised under farming conditions of Bangladesh which further disagrees with the findings of this research, but their result is in agreement with the current study in terms of average daily gain, feed conversion ratio and mortality. Javid-iqval et al. (2012) also reported significant differences in the percentage mortality of few broiler strains raised under local conditions of Pakistan which disagrees with the findings of this research. However, these differences could be due to differences in the environment and nature of the experiments, because the only two strains that were not common to the studies are *Ross 308* and *Hybro*.

Furthermore, Significant differences observed with respect to average daily gain, feed intake water intake, mortality and cost/kg gain and the non-significant difference observed only in feed conversion ratio, of broiler birds fed different energy levels at finisher phase of cold season, coincides with the results reported by Buyse et al. (1992) and Zaho et al. (2004) that showed that growth performance was markedly affected by dietary treatments; broilers fed low levels protein and energy in diets had higher overall mean performance. Similarly, Rahimi and Hassanzadeh (2005) reported significant differences in weight gain, feed intake and mortality of broiler birds placed on diets containing different energy and protein levels, their findings also tallies with that of the current study. Dairo et al. (2012) and Huwaida et al. (2012) have observed significant differences in the average daily gain and feed intake of broiler birds placed on different dietary protein levels, which equally agrees with the findings of this research. Ebling et al. (2013) also reported significant differences in the performance of broiler birds fed different dietary amino acid concentrations which is in line with the findings of this research. On the contrary, Perrault and Leeson (1992) suggested that the feed intake of broiler birds is less dependent on the energy content or requirements of the birds which disagrees with this study. This disagreement could be due to the differences in the energy levels varied in the two separate experiments. It further disagrees with the findings of Dairo et al. (2012) where they reported significant difference ($P<0.05$) in the feed conversion ratio of broiler birds fed different energy/protein combinations. Hassan et al. (2011) reported significant difference in the feed conversion ratio of broiler birds fed different protein levels with enzyme supplementation. This equally disagrees with the findings of this study. Also, Adedeji et al. (2014) reported significant differences in the feed gain ratio of broiler birds fed graded levels of *Aspilla africana,* which also contradicts the findings of the current study.

Kolling et al. (2005) reported non-significant interaction between broiler strains and percentage protein level fed which agrees with the findings of this research, similarly Coneglian et al. (2010) observed non-significant interaction between strains and amino acid concentration fed to broiler strains which further support the findings of this study. These differences could be due to differences in the dietary treatments, strains of the birds involved and even the environment/season in which their experiment was carried out.

CONCLUSION

The study concluded that *Arbor-acre* strain had a lower mortality, cost/kg gain and higher average daily gain compared to other strains. The strain is therefore recommended to be raised and fed low energy diet in the cold season of semi-arid environment of Sokoto, Nigeria.

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