

The Effect of Limestone Deposits as Calcium Source on the Performance of Broiler Chickens

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Abstract

Four trials (two at the starter phase and two at the finisher phase) were carried out in a study that utilized Anak–180 broiler chickens to evaluate the potentials of six limestone sources(that were procured from Ashaka, Calabar, Jakura, Sokoto, Ukpila and Yandev cement factories) for inclusion in broiler diets as calcium source. The control diet accounted for the seventh dietary treatment. The first chick trial (Trial 1) utilized 525 chicks and the second (Trial 2) utilized 420 chicks from day old to 28 days of age. Dietary treatments in each trial were replicated 3 times such that Trial 1 had 25 chicks per replicate and Trial 2 had 20 chicks. The first finisher trial (Trial 3) utilized 315 chickens with 15 birds per replicate, the second (Trial 4) utilized 252 chickens with 12 birds per replicate from 35 days of age to 56 days. The experimental design was Completely Randomized Design. Measurements were taken for, feed intake, body weight gain, efficiency of feed conversion, leg disorders and mortality rate. Results indicated significant (P<0.05) differences in feed intake and weight gain in trial 1. In trial 2, all performance traits were significantly (P<0.05) different among the diets. Both leg disorders and mortality rate occurred in trial 1 but were mild in trial 2. There were no significant (P>0.05) differences among the limestone sources in the performance traits in trial 3, but trial 4 showed significant (P<0.05) differences among the dietary means for feed intake, and weight gain. Generally, the study showed improved performance traits over suggested bench mark standard in this country. Leg disorders did not affect performance traits adversely; both leg disorders and mortality rate were adjudged to be independent of limestone sources tested. It was concluded that, the limestone sources tested were good calcium sources for broiler diets.

Key Words: Limestone sources, broiler chickens, performance traits, leg disorders, mortality rate.

Introduction

Limestone was realized as a source of calcium (Ca) in poultry diets many years ago. McIntyre and Cameron (1951) tested limestone, clamshell and Oystershell as calcium sources for chickens and reported that ground limestone and Oystershell with insoluble grit improved rate of gain and bone mineralization in growing Plymouth Rock chickens. McNaughton and Deaton (1980) reported differences in body weight and bone ash when they incorporated different limestone sources in diets for broilers on "as procured" basis. When the different sources were analyzed for Ca content and incorporated according to broiler chick requirement, the hitherto observed differences due to sources disappeared and there were no more significant differences among treatment means. Until recently in Nigeria, Oystershell, periwinkle shell, bone meal, and imported limestone were the principal Ca sources for poultry diets. The use of bone meal in broiler diets often does not require additional Ca source like those

stated above. However, bone meal has become increasingly unattractive for inclusion in livestock and poultry diets in developed economies of the world due to fears of disease transfer via feed (Mad cow disease, Anthrax, Foot and Mouth disease and more recently, avian influenza).These developed economies of the world, use dicalcium phosphate with limestone in broiler diets. Oystershell and periwinkle shell occur in riverine areas and are costly in the hinterland of the country. Spesfeed (2000) described limestone as a cheap source of Ca for poultry. When Nigerian farmers and consumers of animal products become more conscious of the apparent danger posed by the use of bone meal in livestock diets, dicalcium phosphate and limestone will take the centre stage as Ca source as is practiced else where in the world. Locally available limestone will reduce feed cost when used. Dicalcium phosphate is imported and its price depends on the strength of the Dollar at the time of import. Bone meal is dependent on the number of livestock slaughtered in the locality and sells at One Hundred Naira ($0.63) per kg. Oyster shell/Periwinkle shell may be cheaper in the riverine areas but is costly in the hinterland and sells at Ninety Naira ($0.56) per kg. Limestone sells at Twenty Naira ($0.13) per kg or lower. Prices quoted are prevailing local prices within the year. Limestone sometimes occurs in association with certain minerals (fluorine, selenium) that may be toxic to poultry at certain levels. Smith and Loock cited by Spesfeed (2000) described substances that occur in different locations of South African limestone as impurities and showed that all contained high levels of Silicon (Si), Iron (Fe), Magnesium (Mg) and Manganese (Mn) but no F or Se were reported as component of the impurities. There is need to evaluate the abundant limestone deposits that occur in many parts of this country for their use in broiler rations and recommended safe sources to poultry farmers.

Materials and Methods

Two trials were conducted using Straight-run Anak-180 broiler chicks from day old to 28 days of age in a Completely Randomized Design. Chicks were assigned at random to 21 pens, each of which measured 3.05 x 1.25m^2. The first chick trial (Trial 1) utilized 525 chicks such that each pen had 25 chicks. The second trial (Trial 2) utilized 420 chicks such that each pen had 20 chicks. Chicks were brooded on deep litter floor where kerosene stoves provided heat and bush lamps provided light especially at night. The open sides of the poultry house were covered with Polyethene sheets to conserve heat during brooding. At the end of the 28 day brooding period which terminated the chick trials, chicks were assigned the control diet for a period of 7 days. At the end of the 7 day adjustment period, chicks were 35 days of age. It was possible to separate them into males and females using comb and wattle development.

Chicks were assigned equal numbers of males and females to each pen to minimize sex differences in the finisher phases of the trials. In trial 3, (finisher phase) it was possible to utilize 315 broilers such that each of the 21 pens had 7 males and 8 females (15 broilers per pen). In trial 4 (finisher phase), it was possible to utilize 252 broilers of equal sexes 6 males and 6 females (12 broilers) each in the 21 pens. Chicks were wing-banded and weighed individually at the start of each trial, and weekly thereafter till the termination of each phase of the trials. The finisher phases of the study (trials 3 and 4) also used Completely Randomizes Design. The

Table 1. Mineral composition of limestone sources

Limestone Source	Ca %	Mg %	Fe Mg/kg	Mn Mg/kg	Zn Mg/kg	Cu Mg/kg
Ashaka	38.54	0.30	150.8	557.1	-	-
Calabar	37.80	0.71	761.7	703.5	-	-
Jakura	39.50	0.16	258.3	354.3	28.1	-
Sokoto	38.15	0.50	254.9	-	-	-
Ukpila	38.80	0.25	232.4	400.9	18.2	-
Yandev	38.46	0.44	338.5	-	74.3	-

covered sides of the pens were removed to provide for good cross ventilation. Feed and water were provided *ad libitum* in each trial. Six limestone sources and a control accounted for the seven dietary treatments used in each trial. Trial 1 and 3 utilized limestone sources on "as procured" basis, and dicalcium phosphate was used to balance the phosphorus requirement in the test diets. Bone meal, (a conventional phosphorus source in this country) was used in the control diets. Trials 2 and 4, utilized limestone sources that were chemically analyzed for Ca and some other mineral contents (Table 1). Limestone sources were then incorporated to balance the Ca requirement for broilers. The ratio of Ca: P was widened from 1.5:1 to 2.0:1. This arrangement permitted the incorporation of more Ca from the test materials. Diets were formulated to be essentially iso-nitrogenous and iso-caloric. The energy level of diet 1 was slightly higher in all trials. Each treatment was replicated three times. Calcium determination from sources was carried out at the laboratory of the Ballapur Glass Company Kaduna as outlined below.

1. Calcium Carbonate $CaCO_3$ Determination. A small quantity of source is treated with 1M Hydrochloric acid (HCl) and heated. An indicator (Phenolphthalein) is added. The solution is titrated with 1M Sodium hydroxide (NaOH) solution to get a pink color – suggestive of the presence and amount of $CaCO_3$.

2. Determination of Calcium Oxide (CaO) from $CaCO_3$. A small sample of the prepared $CaCO_3$ is dissolved in hot distilled water and Conc. HCl is added and brought to boil. The solution is filtered through a filter paper, cooled to room temperature and made up to the mark with cold distilled water in 250ml volumetric flask. 0.5g triethylaminehydrochloride is added to 10ml of the solution and allowed to dissolve. 100ml cold distilled water is added and the pH of the solution is adjusted between 12.5 to 13.5 using Potassium hydroxide (KOH). Lime indicator is added and the solution is titrated with standard K5 (tetracetic acid) to get a bluish color which is indicative of the desociation of CaO from $CaCO_3$. The amount of Ca from CaO is determined from molecular formula of CaO.

At the end of the trials, performance data collected from each trial were summarized and analyzed statistically using the one-way analysis of variance (ANOVA), and significant mean values were separated using Duncans New Multiple Range Test as outlined by Steel and Torrie (1980).

Results and Discussion

The Ca content of limestone deposits varied only slightly among the different sources. This may be due in part to the nature of

sampling method adopted by the authors during the procurement exercise. The authors requested to procure limestone from portion of the quarry site that had high calcium carbonate ($CaC0_3$) content. Cement factories usually analyze limestone for $CaC0_3$ content from each portion of quarry site to determine which portion has $CaC0_3$ high enough to be mined. Thus the procured limestones were from sites that contained high $CaC0_3$ content from each factory. Therefore inclusion of the six different limestone deposits as test ingredient in each diet varied only slightly.

Trial 1. Significant differences ($P<0.05$) occurred among treatment groups for feed intake and weight gain. Chicks ate more of the control diet and gained more weight than the tested groups (Table 6). Feed to gain ratio was not affected significantly ($P>0.05$) by the different dietary treatments. Leg disorders (tibia dyschondroplacia, curled toe, perosis) were apparent (1.3 to 4.0%) in this trial. Mortality also occurred in all dietary treatments groups (4.0 to 9.3%).

Trial 2. Significant differences ($P<0.05$) occurred among groups for feed intake, weight gain, efficiency of feed conversion of chicks. However, there were more similarities among mean values in trial 2 than in trial 1 (Table 7). There were no apparent leg disorders and only low mortality rate was observed.

Trials 3 and 4 – Finisher phases. The analysis of all performance data in trial 3 did not show significant ($P>0.05$) differences among the different treatment means values, (Table 8). However, significant differences ($P<0.05$) occurred

Table 2. The composition of diets used in trial 1 (Broiler starter)

Ingredients	Diet identification						
	Control	Ashaka	Calabar	Jakura	Sokoto	Ukpila	Yandev
	%						
G/nut Cake	44.60	44.25	44.25	44.25	44.25	44.25	44.25
Maize	50.40	50.00	50.00	50.00	50.00	50.00	50.00
Bone Meal	4.00	-	-	-	-	-	-
Dicalcium Phosphate	-	3.40	3.40	3.40	3.40	3.40	3.40
Limestone	-	1.35	1.35	1.35	1.35	1.35	1.35
Methionine	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Lysine	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Premix*	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	100	100	100	100	100	100	100
Determined analysis (Dry matter basis)							
Crude Protein (%)	24.66	23.75	24.03	23.48	23.50	23.61	23.55
**Energy: Kcal/kg ME	2930	2920	2910	2895	2915	2918	2925
Ether Extract (%)	6.20	5.91	6.01	5.75	5.87	5.95	5.65
Crude Fiber (%)	4.67	5.01	4.84	4.56	5.12	4.89	4.97
Calcium (%)	1.45	1.25	1.30	1.22	1.35	1.30	1.25
Phosphorus (%)	0.95	0.85	0.82	0.80	0.86	0.85	0.83

**Calculated using Pauzenga (1985) formula, Kcal/kg ME = (37x% CP + 81.8 x % EE + 35.5 x % NFE).

*Premix (Zoodry) Supplied the following additional nutrients per kg of diet:-

Vits: A = 10,000 IU; D_3 = 200 IU; E = 10 IU; K = 2mg; B_1 = 1.5mg; B_2 = 4mg; B_6 = 15mg; B_{12} = 0.01mg;

Pantothenic acid = 5mg; Folic acid = 0.5mg; Biotin = 0.02; Minerals:- Choline chloride = 0.2mg; Mn = 0.8mg; Zn = 0.05mg; Fe = 0.02mg; Cu = 0.005mg; Se = 0.2mg; Co = 0.2mg.

Table 3. The composition of diets used in trial 2 (Broiler starter)

Ingredients	Diet identification						
	Control	Ashaka	Calabar	Jakura	Sokoto	Ukpila	Yandev
	%						
Soyabean Meal	40.00	40.00	40.00	40.00	40.00	40.00	40.00
Maize	55.80	53.80	54.00	54.08	53.90	54.05	53.95
Bone Meal	3.5	-	-	-	-	-	-
Oystershell	-	-	-	-	-	-	-
Dicalcium Phosphate	-	3.4	3.4	3.4	3.4	3.4	3.4
Limestone	-	2.10	1.90	1.82	2.00	1.85	1.95
Methionine	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Salt	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Premix*	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Determined analysis (Dry matter basis)							
Crude Protein (%)	23.45	23.00	23.15	23.20	23.25	23.10	23.13
**Energy: Kcal/kg ME	3014	2944	2952	2954	2948	2953	2950
Ether Extract (%)	5.88	6.91	5.18	6.01	6.21	5.95	5.50
Crude Fiber (%)	2.96	2.68	3.12	2.73	3.25	2.82	3.64
Calcium (%)	1.30	1.61	1.52	1.52	1.56	1.52	1.56
Phosphorus (%)	0.83	0.80	0.75	0.74	0.78	0.72	0.80

**Calculated using Pauzenga (1985) formula, Kcal/kg ME = (37x% CP + 81.8 x % EE + 35.5 x % NFE).

*Premix (Zoodry) Supplied the following additional nutrients per kg of diet:-
Vits: A = 10,000 IU; D_3 = 200 IU; E = 10 IU; K = 2mg; B_1 = 1.5mg; B_2 = 4mg; B_6 = 15mg; B_{12} = 0.01mg; Pantothenic acid = 5mg; Folic acid = 0.5mg; Biotin = 0.02; Minerals:- Choline chloride = 0.2mg; Mn = 0.8mg; Zn = 0.05mg; Fe = 0.02mg; Cu = 0.005mg; Se = 0.2mg; Co = 0.2mg.

among the dietary treatment groups for weight gain and feed intake in trial 4, (Table 9).

Weight gain of chicks in trials 1 and 2 was

Table 4. The composition of diets used in trial 3 (Broiler finisher)

Ingredients	Diet identification						
	Control	Ashaka	Calabar	Jakura	Sokoto	Ukpila	Yandev
	%						
G/nut Cake	36.00	36.00	36.00	36.00	36.00	36.00	36.00
Maize	59.55	58.30	58.30	58.30	58.30	58.30	58.30
Bone Meal	3.5	-	-	-	-	-	-
Dicalcium Phosphate	-	3.4	3.4	3.4	3.4	3.4	3.4
Limestone	-	1.35	1.35	1.35	1.35	1.35	1.35
Methionine	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Lysine	0.20	0.20	0.20	0.20	0.20	0.20	0.20
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Premix*	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	100	100	100	100	100	100	100
Determined analysis (Dry matter basis)							
Crude Protein (%)	21.14	20.76	20.83	20.94	20.85	20.06	20.23
**Energy: Kcal/kg ME	3008	2973	2973	2973	2973	2973	2973
Ether Extract (%)	5.18	4.94	4.87	4.85	4.79	4.80	4.91
Crude Fiber (%)	3.94	4.06	3.41	3.76	3.81	3.75	3.89
Calcium (%)	1.24	1.20	1.23	1.24	1.21	1.22	1.23
Phosphorus (%)	0.80	0.76	0.78	0.70	0.78	0.78	0.80

**Calculated using Pauzenga (1985) formula, Kcal/kg ME = (37x% CP + 81.8 x % EE + 35.5 x % NFE).

*Premix (Zoodry) Supplied the following additional nutrients per kg of diet:-
Vits: A = 10,000 IU; D_3 = 200 IU; E = 10 IU; K = 2mg; B_1 = 1.5mg; B_2 = 4mg; B_6 = 15mg; B_{12} = 0.01mg; Pantothenic acid = 5mg; Folic acid = 0.5mg; Biotin = 0.02; Minerals:- Choline chloride = 0.2mg; Mn = 0.8mg; Zn = 0.05mg; Fe = 0.02mg; Cu = 0.005mg; Se = 0.2mg; Co = 0.2mg.

Table 5. The composition of diets used in trial 4 (Broiler finisher)

Ingredients	Diet identification						
	Control	Ashaka	Calabar	Jakura	Sokoto	Ukpila	Yandev
	%						
Soyabean Meal	33.35	33.35	33.35	33.35	33.35	33.35	33.35
Maize	62.45	60.45	60.65	60.73	60.55	60.70	60.60
Bone Meal	3.5	-	-	-	-	-	-
Oystershell	-	-	-	-	-	-	-
Dicalcium Phosphate	-	3.4	3.4	3.4	3.4	3.4	3.4
Limestone	-	2.1	1.90	1.82	2.00	1.85	1.95
Methionine	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Premix*	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Determined analysis (Dry matter basis)							
Crude Protein (%)	20.35	20.25	20.15	20.25	20.15	20.30	20.15
**Energy: Kcal/kg ME	3041	2974	2980	2984	2978	2982	2980
Ether Extract (%)	3.99	3.40	3.59	3.70	3.19	3.56	3.74
Crude Fiber (%)	2.81	2.86	2.95	3.16	3.14	2.71	3.17
Calcium (%)	1.28	1.69	1.66	1.60	1.63	1.68	1.64
Phosphorus (%)	0.82	0.84	0.83	0.80	0.81	0.84	0.81

**Calculated using Pauzenga (1985) formula, Kcal/kg ME = (37x% CP + 81.8 x % EE + 35.5 x % NFE).

*Premix (Zoodry) Supplied the following additional nutrients per kg of diet:- Vits: A = 10,000 IU; D_3 = 200 IU; E = 10 IU; K = 2mg; B_1 = 1.5mg; B_2 = 4mg; B_6 = 15mg; B_{12} = 0.01mg; Pantothenic acid = 5mg; Folic acid = 0.5mg; Biotin = 0.02; Minerals:- Choline chloride = 0.2mg; Mn = 0.8mg; Zn = 0.05mg; Fe = 0.02mg; Cu = 0.005mg; Se = 0.2mg; Co = 0.2mg.

good in spite of the significant differences that occurred among the treatment mean values. Chicks in Trial 1 gained lower weights on all diets as compared to chicks in Trial 2. The better weight gain of chicks in Trial 2 was thought to be due to the slight increase in energy value and change in protein source used in Trial 2. Dafwang and Ogundipe (1987) suggested a cumulative mean weight of 584g per chick at 28 days of age for practical broiler feeding programme. Most treatment groups in Trial 1, and all treatment groups in Trial 2 produced mean weight values better than the suggested value. In this study, all birds reached finished weight above the 1.8 kg in 56 days of age. Olomu (1979) suggested calcium requirement for broiler to be 1.2% for the tropics. Tion *et al.* (2005) reported that the test limestone sources were equal to oystershell in their solubility and bioavailability rates. The amount of Ca contributed by the basal ingredients was 0.70% and 0.55% Ca was contributed by the tested materials. Tion *et al.* (2005) reported that the bioavailability of Ca from the test limestone sources was higher (87%-90%) than that from the dicalcium phosphate (84.5%) that was used in the basal ingredients. Therefore, Ca from the tested sources contributed to the performance of the broiler chicks. Anderson *et al.* (1984) reported that limestone sources do not confer differences on growth rate. McNaughton and Deaton (1980) reported differences in weight gain among the dietary groups only when the different limestone sources were added to the diets on "as procured" basis. In this study, the differences in weight gain among

Table 6. The effect of limestone sources on performance of broiler chicks (0-28 days of age) Trial 1

Parameters	Limestone Source							
	Control	Ashaka	Calabar	Jakura	Sokoto	Ukpila	Yandev	SEM
Feed intake (g)/bird	1118^{a}	999^{c}	986^{b}	970^{c}	1004^{bc}	1034^{b}	986^{c}	8.98
Wt. gain (g)/bird	596^{a}	536^{c}	504^{d}	536^{c}	524^{c}	572^{b}	516^{d}	5.14
Feed: gain (ratio)	1.87	1.86	1.96	1.83	1.91	1.80	1.91	0.05
Leg disorders (%)*	1.3	1.3	1.3	1.3	2.6	1.3	4.0	-
- Absolute value	1	1	1	1	2	1	3	-
Mortality rate (%)*	9.3	8	4	4	8	9.3	8	-
- Absolute value	7	6	3	3	6	7	6	-

$^{a-d}$Means within a row with same or without superscript do not differ (P>0.05)
SEM = Standard Error of Means.
* = Calculated values.
n = 525

the dietary groups were greatly minimized when the limestone sources were analyzed for Ca content and incorporated in the diets to meet the broiler requirement.

The feed conversion ratios of all diets in all trials of this study compared favorably at every phase with the suggested values for farmers by Dafwang and Ogundipe (1987). This is suggestive of the adequacy of the test limestone sources in commercial broiler production.

Mild leg disorders were apparent on all dietary groups including the control in Trials 1 and 3. These leg disorders did not impair locomotive functions to feeders and waterers. The absence of apparent leg disorders in Trial 2 and only slight incidence (2 cases out of 36 chickens on the diet) in trial 4, both of which had more limestone inclusion rate in the diets gave a clear indication that the leg disorders that occurred in Trial 1 were not caused by diets. Wider Ca:P ratios as were used in this study may not be blamed for the few cases of leg abnormalities that occurred in this study, although the NRC (1994) had suggested a Ca:P ratio between 1.0:1 and 1.5:1. Earlier recommendation by Wilgus cited by Scott *et al.* (1982) stated that, the Ca:P ratios needed for normal results in growing chick vary between 1.0:1 and 2.2:1, and that a ratio of 2.5:1 appeared border line. Leg disorder is an important parameter in commercial broiler production, as it leads in severe cases to, stunted growth, condemnation at the processing plants, and discrimination against the affected birds during sales, low prices, and mortality of

Table 7. The effect of limestone sources on the performance of broiler chicks (0-28 days of age Trial 2)

Parameters	Limestone Source							
	Control	Ashaka	Calabar	Jakura	Sokoto	Ukpila	Yandev	SEM
Feed intake (g)/bird	1151^{b}	1141^{b}	1159^{ab}	1098^{c}	1196^{a}	1170^{ab}	1161^{ab}	13.53
Wt. gain (g)/bird	630^{a}	632^{a}	624^{b}	611^{b}	639^{a}	648^{a}	623^{b}	6.66
Feed: gain (ratio)	1.83^{ab}	1.80^{b}	1.86^{ab}	1.80^{b}	1.87^{a}	1.81^{ab}	1.86^{ab}	0.02
Leg disorders (%)*	0	0	0	0	0	0	0	-
Mortality rate (%)*	0	0	0	1.6	1.6	0	0	-
- Absolute value	0	0	0	1	1	0	0	-

$^{a-b}$Means within a row with same superscript are not significantly different (P>0.05)
SEM = Standard Error of Means.
* = Calculated values.
n = 420

Table 8. The effect of limestone sources on broiler finisher performance Trial 3

	Limestone Source							
Parameters	**Control**	**Ashaka**	**Calabar**	**Jakura**	**Sokoto**	**Ukpila**	**Yandev**	**SEM**
Feed intake (g)/bird	2995	2831	3075	2953	2994	3029	2928	48.27
Wt. gain (g)/bird	1161	1165	1178	1186	1174	1202	1171	30.74
Feed: gain (ratio)	2.58	2.43	2.61	2.49	2.55	2.52	2.50	0.03
Final Body wt. (g)*	2027	1971	1948	1992	1968	2044	1957	
Leg disorders (%)*	8.8	2.2	4.4	4.4	2.2	2.2	4.4	-
- Absolute value	4	1	2	2	1	1	2	-
Mortality rate (%)*	2.2	4.4	4.4	4.4	4.4	2.2	2.2	-
- Absolute value	1	2	2	2	2	1	1	-

Means values within a row are not significantly different (P>0.05)
SEM = Standard Error of Means.
* = Calculated values.
n = 315.

the affected birds. Jordan *et al.* (1996) stated that genetic selection has a major impact on leg disorders. DEFRA (2002) suggested that 60% of lameness was as a result of infections from previous stages in the supply chain and suggested high standard of biosecurity and hygiene that are needed in the parent stock. Low cases of leg disorders that occurred in this study are explained to be independent of dietary treatments, thus, showing that the limestone sources contributed ably to bone mineralization that withstood the rapid growth rate. Cromwell (1982) stated that 99% of Ca is deposited in the skeleton where it complexes with phosphorus to gave bone tissue strength and rigidity.

Mortality occurred in all the trials of this study. In Trial 1 and 2, this included the control. Mortality was therefore unrelated to the test materials. Total mortality in Trial 1 stood and 7.23% Trial 2, was 0.47%, Trial 3, was 2.65% and Trial 4, was 3.06%. Manning *et al.* (2007) stated that mortality is related to slaughter age, the longer the growing cycle, the higher the mortality. The ACP (2006) pegged the benchmark standard of 5% mortality in broiler production irrespective of age. Considering the ACP (2006) benchmark standard, except for Trial 1, all the other trials had mortality rate below that standard. The limestone sources were chemically analyzed (Table 9) for some minerals that occur in association with calcium carbonate in limestone, which may endanger the life

Table 9. The effect of limestone sources on the performance of broiler finisher chickens Trial 4

	Limestone Source							
Parameters	**Control**	**Ashaka**	**Calabar**	**Jakura**	**Sokoto**	**Ukpila**	**Yandev**	**SEM**
Feed intake (g)/bird	3528^{bc}	3444^{c}	3516^{bc}	3572^{ab}	3578^{ab}	3660^{a}	3539^{bc}	33.69
Wt. gain (g)/bird	1411^{c}	1453^{b}	1435^{bc}	1464^{b}	1414^{c}	1551^{a}	1427^{bc}	12.24
Feed: gain (ratio)	2.5	2.37	2.45	2.44	2.53	2.36	2.48	0.06
Final Body wt. (g)*	2311	2355	2329	2345	2323	2469	2330	-
Leg disorders (%)*	0	0	0	0	5.56	0	0	-
- Absolute value	0	0	0	0	2	0	0	-
Mortality rate (%)*	0	0	11.11	0	0	0	8.33	-
- Absolute value	0	0	0	0	0	0	3	-

$^{a-d}$Means within a row with same or without superscript do not differ (P>0.05)
SEM = Standard Error of Means.
* = Calculated values.
n = 252

of chickens. Fluorine (F) appears to be the most dreaded of these minerals. Gardiner *et al.* cited by NRC (1994) reported that (F), when it occurs as calcium fluoride (Ca F) can be fed to immature chicks at 500 ppm without causing harm to the chicks. Berg and Martinson (1972) reported reduced growth rate in chicks when they included 750 ppm F in the Feed. Selenium (Se) is another of these toxic minerals. Jensen (1975) mixed up to 20 ppm Se with Ca in feed before he reported retarded growth rate in chicks. Although, chemical analysis for F and Se were not carried out due to functional equipment problem, good growth rate and low mortality even at the starter phase of Trial 2 and 4, that had higher concentration of the test limestone sources was an indication that these minerals, if at all they occurred in association with calcium carbonate in the limestone sources, were not high enough at the rate, the test materials were incorporated in diets, to produce noticeable harmful effect on the broiler chickens. Other minerals like Magnesium ($MgC0_3$) require higher levels 6000 ppm (Chicco *et al.*, 1967), 6400 ppm (Nugara and Edwards 1963), to produce retarded growth rate in chicks. Although, this mineral was present in all the analyzed samples of the limestone sources, it was not high enough to produce adverse effect on chick growth, hence the good growth rate earlier reported.

Conclusion

The limestone sources were investigated for abnormally high levels of the minerals that could endanger broiler production when the sources are included in rations. Good performance and other associated parameters (leg disorders and mortality rate) that make for successful broiler production showed that, the limestone sources used in this study are safe for inclusion in poultry diets as Ca source for commercial broiler production.

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