Ife Journal of Agric. Vol. 11 Nos. 1 & 2 (1989)

Calcium, phosphorus and manganese content and availability in poultry feeds

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Abstract:

The calcium (Ca), phosphorus (P) and manganese (Mn) contents of common tropical poultry feeds were determined by spectroscopic methods. Mn content ranged from 9.1 mg/kg in maize to 145 mg/kg in oyster shell; Ca ranged from 0.03% in maize to 37.5% in oyster shell; and P ranged from 0.01% in palm oil to 14.12% in bone meal. The commonly used energy, protein and mineral sources contained low, medium and high mineral contents respectively.

One hunred and eight (108) four-week old broiler chicks were used to estimate the biological availability of Ca, P and Mn in maize, groundnut cake (GNC), fish meal (FM), bone meal (BM), oyster shell (OS) and manganese sulphate (Mn. SO_4). The availability from maize, GNC, FM, BM and OS were found to be 53.9, 71.1, 89.4, 94.6 and 96.5% for Ca; 40.8, 59.1, 90.4, 88.1 and 90.6% for P; 64.2, 61.4, 93.7, 81.3 and 99.3% for Mn respectively. Availability of Mn from $MnSO_4$ was 90% The biological availability of Ca. P and Mn in the feeds tested differed ($P \leq 0.05$) from each other, and P availability from feeds of plant origin was higher than the value of 33% conventionally reported.

Introduction

Mineral element deficiencies and excesses continue to cause frank disease or reduce the productivity of livestock in developed and developing countries (Miles 1981). Mineral elements are derived from the feeds which animals consume as well as from inorganic compounds of soil and industrial origin. The importance of a feed as a source of mineral nutrients depends on the concentration of the mineral in the feed as well. as on the availability of the mineral from the feed, when in the gastrointestinal tract. Although evidence exist that soil type and climate are among the factors affecting plant mineral contents (underwood 1981), feed nutrient composition tables compiled for feeds of temperate origin are still largely used to formulate diets of livestock in many developing countries because of the non-availability of local feed ingredient tables.

Little information is available as to the extent of biological availability of different incorganic elements contained in various feeds of tropical origin. The present study was designed to investigate the content and availability to broilers of Ca, P, and Mn in tropical livestock feeds. Calcium, phosphorus and manganese were studied together, because of their interrelationships in the aetiology of perosis (Schaible *et al* 1938; Davis 1959), a legbone abnormality prevalent in broilers in Nigeria (Smith and Olubunmi 1983).

Materials and methods

Representatives samples of common sources of energy, protein and minerals commonly used to compound poultry diets in Nigeria were obtained from various suppliers for the study. The samples were oven dried and ground to pass through a 1mm sieve. Duplicate 2g samples per feeds were then dry ashed in a muffle furnace at 500°C for 12 hours and the ash extracted for mineral analyses as described by Buchanan - Smith *et al* (1974). Phosphorus was determined by the phosphovanadomolybdate method (AOAC 1975) while Mn and Ca were determined using a

Perkin Elmer atomic absorption spectrophotometer. Lanthanum oxide was added to the extract solution used for calcium determination at the rate of 0.1% (W/V) to suppress interference from P.

The availability to broilers of Mn in $MnSO_4$ and Ca, P and Mn in maize, groundnut, cake, fish meal, bone meal and oyster shell was determined using a mineral balance procedure described by Nwokolo *et al* 1976. The procedure provides for the estimation of endogenous mineral excretion by feeding a purified diet. Faecal collection is aided by feeding a marker before and after feeding either a purified diet or the test material.

In this study a total of 108 four-week old Cobb broilers were randomly distributed into 18 cages in groups of 6 chicks per cage. The cages were then randomly assigned to the six test diets to give 3 cages per diet. On day 1 of the experimental period, all chicks were fed a mash containing 0.3% ferric oxide as a marker for 4 hours, then fasted for 16 hours. The fasting period was followed by a 4 hour period during which chicks were fed a purified diet whose composition is shown in Table 1.

TABLE 1. COMPOSITION OF PURIFIED DIET

Ingredients	Amount (%)
Sucrose	81
Cellulose	9
Maize oil	10

The chicks were again fed the marker diet for another 4 hours period. The unmarked faeces were quantitatively collected from each cage, and assumed to have come from the purified diet. The procedure was then repeated except that the purified diet was substituted with the test feed, such that each test feed was fed to 18 broilers in replicates of 3. Since the test feeds are usually not fed alone in practice, each feed was mixed with the purified diet in proportions that approximate levels fed in practical diets. Table 2 shows the proportions of the test feeds incorporated into the experimental diets.

During the experimental period, the chicks were given distilled de-ionized water *ad libitum*. Feed and water troughs were lined with polythene sheets to reduce mineral contamination. Test feed and faecal samples were dried to constant weight at 85°C for dry matter determinations and ground to pass through a 1mm sieve. The Ca, P and Mn content of the samples were determined as described earlier.

TABLE 2: PROPORTIONS OF TEST FEEDS IN EXPERIMENTAL DIETS (% AIR DRY BASIS)

	Maize	GNC	FM	BM	OS	$MnSo_4$
Test Feed	60	30	10	3.91	2.8	0.022
Purified diet mixture	40	70	90	96.09	97.2	99.978

Percent mineral availability (A%) of each feed was calculated as:

$$A\% = \frac{(FM + EFM) \times 100}{TMI}$$

TMI = Total mineral intake
FM = Faecal mineral
EFM = endogenous faecal mineral

Mineral availability data were subjected to analysis of variance and significant means separated by Tukey's W procedure (Steel and Torrie 1960).

Results and discussion

The mineral contents of the feeds analysed are shown in Table 3. The results show that energy sources such as cereals, cereal by-products and palm oil have very low levels of Ca and P while protein sources both animal and plant have medium to high levels of both minerals. As expected the mineral sources (bone meal, oyster shell) had very high levels except that oyster shell had very little amount of phosphorus (0.05%). The calcium and phosphorus levels of the energy and protein sources show that when fed at the normal dietary levels, these feed ingredients cannot supply the minimal nutritional requirements of broilers for calcium and phosphorus.

TABLE 3: CALCIUM, PHOSPHORUS AND MANGANESE CONTENTS OF POULTRY FEEDSTUFFS.

Feed	Ca (%)	P (%)	Ca:P	Mn (mg/kg)
Yellow maize	0.03	0.3	1:10	9.1
Sorghum	0.04	0.03	1:0.8	11.0
Palm oil	Trace[1]	0.01	—	Trace[2]
Rice bran	0.07	0.4	1:5.7	80.0
Brewers dried grains (BDG)	0.55	0.46	1:0.8	43.2
Groundnut cake (GNC)	0.20	0.09	1:0.5	25.2
Soyabean meal	0.20	0.45	1:2.3	22.5
Winged bean meal	0.15	0.5	1:3.3	28.1
Fish meal	4.0	2.15	1:0.5	16.25
Bone meal	29.0	14.12	1:0.5	42.5
Oyster shell	37.5	0.05	—	145.0

[1]Detection limit = 0.08 mg/ml
[2]Detection limit = 0.055 mg/ml

Manganese content varied from a low level of 9.1 mg/kg for maize to a high level of 145 mg per kg for oyster shell (Table 3). When compared with the recommended broiler requirement of 55mg Mn/kg of feed (NRC 1977), manganese content of the cereals are low while the concentration in cereal by-products - BDG and rice bran -and high. All animal protein sources assayed had low Mn content. These observations agree with the report of Underwood (1981) that protein concentrates of animal origin are poor Mn sources and that of Scott *et al* (1976) that cereal brans are rich sources of Mn. Cereals, animal and plant protein sources which are poor in Mn, usually make over 80% of the total broiler diet. Most broiler diets would therefore need a high supplemental level of manganese even if all Mn in the feed ingredients were available.

Table 4, however, shows that Mn present in maize, GNC and fish meal, the commonly used broiler feed ingredients is not all available although over 90% was available in fish meal, a protein feed of animal origin.

TABLE 4: PERCENT AVAILABILITY OF CALCIUM, PHOSPHORUS AND MANGANESE IN TEST FEEDS

	Availability (%)						
	Maize	GNC	FM	BM	OS	MnS04	Se[1]
Calcium	53.9^{a}	71.1^{b}	89.4^{c}	94.6^{d}	96.5^{d}	—	1.0
Phosphorus	40.8^{a}	59.1^{b}	90.4^{c}	88.1^{c}	90.6^{c}	—	0.04
Manganese	64.2^{a}	64.1^{a}	93.7^{b}	81.3^{c}	99.3^{d}	99.0^{d}	0.7

[1]Standard error, N = 3 observations

a,b,c,d, Means on the same row with different letters are different (P 0.05).

P availability in maize (40.8%) and GNC (59.1%) two plant materials was higher than the value of 33% usually reported (NRC 1977; Taylor 1965) for plant materials. Perhaps as suggested by Nwokolo *et al* (1976), P availability of feedstuffs of plant origin has hither-to been underestimated. The Ca, P and Mn content of the commonly used mineral supplements were not only high but also highly available. This combination justified the usually low quantities of these ingredients used to supplement complete diets.

In general Ca, P and Mn availabilities to broiler chicks were significantly lower (P .05) in energy feeds than in protein feeds. Within protein feeds, availability was lower (P 0.05) for feeds of plant origin than those of animal origin. The mineral supplements evaluated had higher (P 0.05) availability values than the energy and protein feeds regardless of their origin.

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