Animal Feed Science and Technology 206 (2015) 100–107

Contents lists available at ScienceDirect

Animal Feed Science and Technology

journal homepage: www.elsevier.com/locate/anifeedsci

Measurement of true ileal calcium digestibility in meat and bone meal for broiler chickens

M.N. Anwar[a], V. Ravindran[a,*], P.C.H. Morel[a], G. Ravindran[b], A.J. Cowieson[c]

[a] Institute of Veterinary, Animal and Biomedical Science, Massey University, Palmerston North 4442, New Zealand
[b] Institute of Food, Nutrition and Human Health, Massey University, Palmerston North 4442, New Zealand
[c] Poultry Research Foundation, University of Sydney, Camden, NSW 2570, Australia

ARTICLE INFO

Article history:
Received 13 March 2015
Received in revised form 20 May 2015
Accepted 21 May 2015

Keywords:
Calcium
Digestibility
Meat and bone meal
Broilers

ABSTRACT

The objective of the present experiment was to determine the true ileal calcium (Ca) digestibility in three samples of meat and bone meal (coded as MBM-1, MBM-2 and MBM-3) for broiler chickens. Four experimental diets, containing graded concentrations of Ca, were formulated from each MBM sample with inclusion levels of 20, 40, 60 and 80 g/kg diet. Each experimental diet was randomly allotted to four replicate cages (six birds per cage) and fed for three days from day 28 post-hatch. Apparent ileal digestibility coefficient of Ca was measured by the indicator method and linear regression analysis was used to determine the true Ca digestibility coefficient. Apparent Ca digestibility was unaffected ($P > 0.05$) by increasing Ca concentrations. The apparent digestibility coefficients in MBM-1, MBM-2 and MBM-3 were 0.50, 0.44 and 0.45, respectively. Significant linear ($P < 0.001$) relationship was observed between dietary Ca intake and digesta Ca output for MBM-1, MBM-2 and MBM-3 with R^2 values of 0.82, 0.93 and 0.95, respectively. The true ileal digestibility coefficients of Ca in MBM-1, MBM-2 and MBM-3 were determined to be 0.60, 0.46 and 0.50, respectively. The corresponding ileal endogenous Ca losses were 292, 123 and 174 mg/kg dry matter intake, respectively.

1. Introduction

Determination of calcium (Ca) digestibility in feed ingredients for poultry has not received any attention in the past due to the abundance and low cost of limestone, the major inorganic Ca source, and the low Ca concentration in plant feed ingredients. However, the recent interest in the determination of phosphorus (P) digestibility in feed ingredients (WPSA, 2013) necessitates the measurement of Ca digestibility because of the close relationship between P and Ca metabolism. It is well recognised that high dietary Ca concentrations reduce the availability of P in broiler chickens (Ballam et al., 1984; Tamim et al., 2004; Tamim and Angel, 2003; Plumstead et al., 2008).

Currently there is no established method available for the determination of Ca digestibility in poultry. However, three different methods, namely direct, difference and regression, are used for the determination of amino acid digestibility in feed ingredients (Ravindran and Bryden, 1999; Lemme et al., 2004). Some recent studies have used the regression method for the

Abbreviations: DM, dry matter; Ca, calcium; P, phosphorus; CP, crude protein; Ti, titanium dioxide; MBM, meat and bone meal; GMD, geometric mean diameter; GSD, geometric standard deviation; DMI, dry matter intake; AIDC, apparent ileal digestibility coefficient; TIDC, true ileal digestibility coefficient.

* Corresponding author. Tel.: +64 6 350 5528; fax: +64 6 350 5684.
E-mail address: V.Ravindran@massey.ac.nz (V. Ravindran).

http://dx.doi.org/10.1016/j.anifeedsci.2015.05.018
0377-8401/

Table 1
Ingredient composition and analysis (g/kg as-fed basis) of meat and bone meal (MBM) based diets.

	MBM-1				MBM-2				MBM-3			
	20	40	60	80	20	40	60	80	20	40	60	80
Dextrose	717.2	701.6	686.08	670.48	717.2	701.6	686.08	670.48	717.2	701.6	686.08	670.48
Maize starch	179.3	175.4	171.52	167.62	179.3	175.4	171.52	167.62	179.3	175.4	171.52	167.62
Cellulose	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Meat and bone meal	20.0	40.0	60.0	80.0	20.0	40.0	60.0	80.0	20.0	40.0	60.0	80.0
Soybean oil	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Sodium chloride	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Potassium chloride	3.1	2.6	2.0	1.5	3.1	2.6	2.0	1.5	3.1	2.6	2.0	1.5
Titanium dioxide	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Trace mineral–vitamin premix[a]	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Calculated analysis												
Metabolisable energy (MJ/kg)	15.17	15.04	14.91	14.78	15.17	15.04	14.91	14.78	15.17	15.04	14.91	14.78
Crude protein	10.72	21.45	32.17	42.89	9.75	19.5	29.25	39.00	9.48	18.97	28.45	37.94
Calcium[b]	1.43	2.86	4.30	5.73	2.36	4.72	7.09	9.45	2.29	4.58	6.88	9.17
Total phosphorus[b]	0.75	1.50	2.25	3.00	1.20	2.41	3.61	4.81	1.20	2.39	3.59	4.78
Non-phytate phosphorus	0.75	1.50	2.25	3.00	1.20	2.41	3.61	4.81	1.20	2.39	3.59	4.78
Analysed values (as-fed basis)												
Dry matter	912	915	915	915	916	917	916	917	915	916	916	919
Calcium	1.40	2.36	4.05	5.72	2.19	4.58	6.95	8.53	1.91	4.04	5.89	8.73
Phosphorus	1.11	1.68	2.36	3.59	1.35	2.75	4.22	5.15	1.42	2.32	3.78	4.85

[a] Supplied per kilogram of diet: vitamin A, 18,000 IU; cholecalciferol, 6000 IU; thiamine, 4.5 mg; riboflavin, 13.5 mg; pyridoxine, 15 mg; folic acid, 4.5 mg; biotin, 0.38 mg; cyanocobalamin, 0.03 mg; DL-α-tochopherol acetate, 120 mg; niacin, 90 mg; Ca-D pentothenate, 22.5 mg; menadione, 6 mg; choline chloride, 900 mg; Co, 0.37 mg; I, 2.20 mg; Mo, 0.37 mg; Se, 0.38 mg; Mn, 147 mg; Cu, 15 mg; Zn, 117 mg; Fe, 88 mg; antioxidant, 147 mg.
[b] Calculated based on analysed values of MBM sample.

determination of P digestibility in poultry (Dilger and Adeola, 2006; Liu et al., 2013; Mutucumarana et al., 2014a,b). In the regression method, diets containing graded concentrations of the specific nutrient from the assay ingredient are formulated and fed to birds. This method is based on establishing a linear relationship between dietary nutrient input and their output in ileal digesta, expressed as g/kg dry matter of diet and digesta, respectively. The digestibility estimate determined as the slope of the linear regression is automatically corrected for endogenous losses and represents the true digestibility value.

Meat and bone meal (MBM) is an important organic Ca source in poultry diets and contains an average of 103 g/kg Ca (NRC, 1994). But wide variations have been found in the Ca concentration of MBM from different sources. Calcium concentration of MBM is reported to range from 40 to 150 g/kg (Waldroup, 1999; Sulabo and Stein, 2013). Apparent total tract digestibility of Ca in eight MBM samples for pigs has been recently reported (Sulabo and Stein, 2013), but there is no published data available for poultry. The purpose of the study reported in the present paper was to determine the true ileal digestibility of Ca in three MBM samples for broiler chickens.

2. Materials and methods

The experiment was conducted according to the New Zealand Revised Code of Ethical Conduct for the use of live animals for research, testing and teaching, and approved by the Massey University Animal Ethics Committee.

2.1. Diets and experimental design

Meat and bone meal samples from three commercial rendering plants (coded as MBM-1, MBM-2 and MBM-3) were obtained and representative samples were analysed in triplicate for dry matter (DM), crude protein (CP), crude fat, ash, Ca and P, particle size distribution and, meat and bone fractions. For each MBM sample, four semi-purified diets were formulated with graded inclusions of MBM (20, 40, 60 and 80 g/kg) to maintain graded dietary Ca concentrations (Table 1). Inclusion levels of MBM were maintained below 80 g/kg to ensure that the dietary Ca concentrations were less than the recommended Ca requirement for broiler finishers (Ross, 2007). Meat and bone meal served as the sole source of Ca in all diets and the Ca:total P ratio was calculated to be around 2:1. Titanium dioxide (3 g/kg) was incorporated in the diets as an indigestible marker.

2.2. Birds

Day-old male broilers (Ross 308) were obtained from a local hatchery and were raised on floor pens in an environmentally controlled room. Temperature was maintained at 31 °C on day 1 and gradually reduced to 24 °C by day 21, and then maintained at 24 °C till day 31. The birds were fed commercial broiler starter crumbles till day 14. On day 15, birds were