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## Digestible Calcium in Meat and Bone Meal

There is an increasing need for determining nutrient digestibility in all feedstuffs available. Of particular concern is digestible phosphorus in diets because of environmental concerns and increasing prices of available phosphates. Since dietary calcium is closely related to dietary phosphorus, the same digestible calcium concentrations need to be measured in feedstuffs as well. The assumption is that calcium in meat and bone meal (MBM) is readily available as a nutrient. Nutritionists have assumed nearly 100% availability from animal byproducts and inorganic ingredients such as MBM, poultry byproduct meal, fish meal, limestone, dicalcium phosphate, and other calcium sources. Recent research suggests this may not be the case and that it may be closer to 50%.

In February of last year, 73 research papers were presented at the 27th Annual Australian Poultry Science Symposium. This event is organized by the Poultry Research Foundation at the University of Sydney and the Australian branch of the World's Poultry Science Association. Anwar, et al., (2015) presented a paper on measuring true ileal calcium digestibility of (MBM) for broilers. This is original research with no published data on available or digestible calcium content of MBM for poultry, as noted by the researchers.

The researchers used three MBM samples, (analyzed for ash, calcium and phosphorus concentrations, particle size and bone-to-soft tissue ratio, Table 1). Each sample was used in four experimental diets in progressive concentrations of calcium. Concentration levels were 2%, 4%, 6% and 8%. The experiment used 288 one-day-old male broilers. Birds were fed a commercial broiler diet for days 1-27. Then, birds were divided into replicates and fed the treatment diets from days 28-31. Samples were collected on day 31 and analyzed for dry matter and calcium.

Increasing calcium concentrations did not affect the apparent ileal calcium digestibility of the MBM samples. Researchers did find a strong linear relationship between dietary calcium intake and

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digesta calcium output in all of the MBM samples. Specifically, the calcium digestibility of MBM-1 was significantly higher than MBM-2, but not significantly different from MBM-3. There was no significant difference in calcium digestibility between MBM-2 and MBM-3. The researchers suggest the variability in true calcium digestibility may be explained by difference in ash, calcium concentrations and bone-to-soft tissue ratios.

To accurately account for digestible nutrient concentrations (both with and without enzyme supplementation), all feed ingredients need to be re-evaluated by the industry. This research will benefit production performance and have an improved economic benefit. Diet formulations based on a better understanding of nutrient availability may also be expected to have a more positive environmental impact.

*Information for this article taken from:*


Dudley-Cash, B. 2015. Digestible calcium in MBM varies for broilers. *Feedstuffs*. April 6, 2015: 14-15.

Anwar, M., V. Ravindran, P. Morel, G. Ravindran, A. Cowieson, (2015). Measurement of true ileal calcium digestibility in meat and bone meal for broiler chickens. Animal Feed Science and Technology, 206: 100-107.


Complete Symposium findings may be found at [http://sydney.edu.au/vetscience/apss](http://sydney.edu.au/vetscience/apss).

**Table 1. MBM Analysis and research results**

| | --- Analysis, % --- | | ------------------- Results ------------------- | | | |
|---|---|---|---|---|---|---|
| **Sample** | **Calcium** | **Phos.** | **GMD[1]** | **Bone:soft tissue** | **ACaD[2]** | **TCaD[3]** |
| MBM-1 | 7.1 | 3.7 | 0.866 | 1:1.49 | 0.501 | 0.600 |
| MBM-2 | 11.8 | 6.0 | 0.622 | 1:0.98 | 0.436 | 0.463 |
| MBM-3 | 11.4 | 5.9 | 0.875 | 1:0.92 | 0.453 | 0.497 |

1 Geometric mean particle diameter, mm.

2 Apparent calcium digestibility coefficient.

3 True calcium digestibility coefficient.

# Digestible Phosphorus in Meat and Bone Meal

Meat and bone meal (MBM) is a common ingredient in poultry diets. It is a good source of amino acids, calcium (Ca) and phosphorus (P), but these nutrients are highly variable in the product. Extensive research has been done to evaluate the relative bioavailability of P in MBM in pig and poultry diets, but this is not an indication of actual P availability in MBM. Currently, the preferred evaluation is to assess true P digestibility to determine P availability.

Some research on this preferred determination method exists for pigs, but not for poultry. Mutucumarana, et al, (2015), conducted a recent study to determine the true ileal P digestibility of three MBM samples for broilers.

## Experiment

Researchers used 432 one-day-old male broilers (Ross 308) and fed them a commercial starter diet until day 20. On day 21, the birds were divided into 12 groups of six birds each. Twelve treatment diets were formulated using three MBM samples (MBM-1, MBM-2, and MBM-3). Each MBM sample was analyzed for dry matter (DM), total P, Ca, Crude Protein (CP), ash and crude fat. Particle size distribution was determined. Calculations were also made for the geometric mean diameter (GMD) and geometric standard deviation (GSD) of the MBM samples.

In this experiment, MBM-1 technically qualified as meat meal, but for research purposes, all MBM samples were considered to be MBM. The variation in composition between the MBM samples is largely due to the differences in the type of raw material used (mammalian tissues, including bone, excluding: blood, hair, hoof, horn, hide trimming, manure and stomach and rumen contents, (except for what cannot be avoided in good processing practices; AAFCO, 2000).

Diets with increasing amounts of total P were formulated. Each sample was used in four diets in increasing amounts (20, 40, 60 and 80 MBM g/kg, respectively; Table 1). The levels of MBM included were chosen so that dietary P content would be maintained below requirements, necessary for statistical analysis. In the treatment diets, MBM was the only source of P. Calcium to nonphytate P ratios were maintained at 2:1 in all diets.

**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 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Diet 1** | **Diet 2** | **Diet 3** | **Diet 4** | **Diet 1** | **Diet 2** | **Diet 3** | **Diet 4** | **Diet 1** | **Diet 2** | **Diet 3** | **Diet 4** |
| **MBM** | 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 |
| **Dextrose** | 717.2 | 701.6 | 686.1 | 670.5 | 717.2 | 701.6 | 686.1 | 670.5 | 717.2 | 701.6 | 686.1 | 670.5 |
| **Corn starch** | 179.3 | 175.4 | 171.5 | 167.6 | 179.3 | 175.4 | 171.5 | 167.6 | 179.3 | 175.4 | 171.5 | 167.6 |
| **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 |
| **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 |
| **Salt** | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| **Titanium dioxide (marker)** | 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**[1] | 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*** | | | | | | | | | | | | |
| **ME (kcal/kg)** | 3,623 | 3,592 | 3,561 | 3,530 | 3,623 | 3,592 | 3,561 | 3,530 | 3,623 | 3,592 | 3,561 | 3,530 |
| **CP**[2] **(g/kg)** | 10.72 | 21.44 | 32.16 | 42.88 | 9.76 | 19.52 | 29.28 | 39.04 | 9.48 | 18.96 | 28.44 | 37.92 |
| **Ca**[2] **(g/kg)** | 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 P**[2] **(g/kg)** | 0.75 | 1.50 | 2.25 | 3.00 | 1.20 | 2.41 | 3.61 | 4.81 | 1.20 | 2.39 | 3.59 | 4.78 |
| **Nonphytate P**[2] **(g/kg)** | 0.75 | 1.50 | 2.25 | 3.00 | 1.20 | 2.41 | 3.61 | 4.81 | 1.20 | 2.39 | 3.59 | 4.78 |
| **Ratio of Ca to nonphytate P** | 1.91:1 | 1.91:1 | 1.91:1 | 1.91:1 | 1.96:1 | 1.96:1 | 1.96:1 | 1.96:1 | 1.92:1 | 1.92:1 | 1.92:1 | 1.92:1 |
| ***Analyzed values*** | | | | | | | | | | | | |
| **Ca (g/kg)** | 1.40 | 2.36 | 4.05 | 5.72 | 2.19 | 4.58 | 6.95 | 8.53 | 1.91 | 4.04 | 5.89 | 8.73 |
| **Total P (g/kg)** | 1.11 | 1.68 | 2.36 | 3.59 | 1.35 | 2.75 | 4.22 | 5.15 | 1.42 | 2.32 | 3.78 | 4.85 |

[1] Supplied per kg of diet: Co, 0.3 mg; I, 1.5 mg; Mo 0.3 mg; Se 0.3 mg; Mn 100 mg; Cu, 10 mg; Zn, 80 mg; Fe, 60 mg; antioxidant, 100 mg; vitamin A, 12,000 IU; vitamin $D_3$, 4,000 IU, thiamine, 3 mg; riboflavin, 9mg; pyridoxine, 10 mg; folic acid, 3 mg; biotin, 0.25 mg; vitamin $B_{12}$, 0.02 mg; vitamin E, 80 mg; choline chloride, 0.6 g; nicotinic acid, 60 mg; Ca pantothenate, 15 mg; menadione, 4 mg.
[2] Calculated based on values determined for individual MBM samples.

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Digesta samples were collected and analyzed on day 24.

## Findings

Table 1 also shows the analysis results of the diets' Ca content. Concentrations of P and Ca both increased with the increasing concentrations of MBM in the diet. The nutrient composition of the MBM samples is shown in Table 2. The relative particle size distribution of particles greater than 1.0 mm (coarse) and 0.5-1.0 mm (medium) was higher in MBM-1 and MBM-3, compared to MBM-2. The geometric mean diameter (GMD) of MBM-1, MBM-2 and MBM-3 was calculated to be 866, 622, and 875 µm, respectively. The geometric standard deviation (GSD) were 1.53, 1.95 and 1.51 (µm), respectively. During the three day experimental period, the birds remained healthy. All four levels of MBM amounts resulted in weight loss.

The resulting weight loss on all four treatment diets may be explained as a result of protein deficiency, as suggested by the researchers. The diets were all protein deficient and calculated too much below the recommended requirements of 210-230 g/kg CP for broiler growers (Ross, 2007).

Regardless of MBM sample, increasing the dietary concentrations of P linearly increased ileal P outputs. There is a strong relationship between ileal P output and dietary P content in all the MBM samples. For each MBM sample, the true ileal P digestibility coefficient was determined to be 0.693 (MBM-1), 0.608 (MBM-2) and 0.420 (MBM-3). Ileal endogenous P loss was estimated at 0.049 (MBM-1), 0.142 (MBM-2) and -0.370 (MBM-3) g/kg DMI for each MBM sample.

## What this means for the industry

This is original research for broiler chickens. This research showed that the apparent ileal digestibility of P is dependent on the inclusion level of MBM and that P in bone fraction is less digestible than P in soft tissue fraction. It is important to keep in mind the bone-to-soft tissue ratios of the MBM sources when formulating diets. Particle size distribution may also influence the digestibility of P in MBM. Bone meal texture has been shown to influence P utilization in broilers too (Orban and Roland, 1992).

The analysis method used to determine apparent digestibility may not always be reflective of the actual digestibility, which may be lower than originally estimated by current standards. Based on this research, the P in MBM may not be highly digestible, which nutritionists and those who formulate poultry diets should keep in mind.

*Information for this article taken from:*

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**Table 2. Analyzed composition of meat and bone meal (MBM) samples (g/kg, as-fed basis)**

| | MBM-1 | MBM-2 | MBM-3 |
|---|---|---|---|
| CP (nitrogen x 6.25) | 536 | 488 | 474 |
| Crude Fat | 114 | 93 | 88 |
| Ash | 237 | 357 | 362 |
| Total P | 37.54 | 60.17 | 59.8 |
| Ca | 71.59 | 118.1 | 114.6 |