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## Meat and Bone Digestibility Standards?

There are many sources of phosphorus and calcium from feed ingredients. In addition to cost consideration, environmental concerns are driving producers and manufacturers to be more aware and more closely monitor nutrient composition, concentration and utilization of ingredients. Recent articles have reported on the bioavailability of phosphorus and calcium from plants and in the presence of phytase. Another effective source of protein and nutrients in swine diets is from meat and bone meal (**MBM**).

Meat and bone meal comes from the unusable and unsellable products of slaughtered livestock in the rendering industry. These include fat, unsellable retail meat products and whole condemned carcasses. Animal hair, blood, hooves, horns and the contents of the gastrointestinal tract are not included and are not part of meat and bone meal. The Association of American Feed Control Officials (2011) classify MBM as containing at least 4.0% P and the Ca:P ratio is not greater than 2.2. This ingredient is primarily used as a protein source that happens to contain more phosphorus and calcium concentrations than all plant feed ingredients. This provides an easy argument to make for considering using MBM as a replacement for inorganic phosphates that will not negatively affect the bone integrity and growth performance of growing pigs.

In order to make this substitution in ingredients, an accurate assessment of nutrient availability and digestibility is critical. Research to date has reported relatively high variability in both the concentration and bioavailability of phosphorus, and the concentration of calcium in MBM. Very little research has looked at the bioavailability of calcium in MBM. In feed ingredients, standardized total tract digestibility (**STTD**) of P is used as an indicator of phosphorus availability. This is calculated by correcting values for the apparent total tract digestibility (**ATTD**) of P for standard internal P losses. In plant feed ingredients, these values are well established. In MBM sources, this is a poorly researched subject to date.

To address this issue, Sulabo and Stein, (2013) conducted an experiment with three objectives. The first looked at eight different sources of MBM to determine the ATTD and STTD of phosphorus and the

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ATTD of calcium. Secondly, the study estimated variation among MBM sources. The authors also proposed equations they developed to predict concentrations of digestible phosphorus and calcium in MBM sources.

**Experiment**

The experiment involved 8 sources of MBM from 5 different companies, with seven sources produced from "mixed species" and one consisting of tissue obtained from pigs. In total, 72 barrows were split into two groups of 36 pigs as determined by date of birth. The pigs were randomly assigned to nine dietary treatments based on their initial body weight. Metabolism cages were utilized in this study for the total collection of feces.

One of the nine diets was a P-free diet. The other eight diets were formulated to include cornstarch, sucrose, soybean oil, sodium chloride, vitamin-mineral premix, and 8% of the assigned source of MBM for each diet. The P-free diet was used to determine the basal endogenous P losses (**EPL**). No inorganic P or Ca was added to the eight diets that contained MBM. In those diets, the only source of P and Ca in the diet was the MBM.

The pigs were fed equal amounts two times per day at three times their estimated energy maintenance requirements. The first five days were a period of adjustment to the diets. Feces were collected between days 6 and 11, and then frozen immediately for later analysis.

The authors determined the ATTD of P in each diet, which also determined the ATTD of the MBM source since it was the only P source in the diet. The P-free diet was used to determine the basal EPL. In the P-containing diets, daily basal EPL (mg/kg of DMI) was determined by multiplying the calculated EPL (from the P-free diet) per kilogram of DMI by the daily DMI of each pig. The ATTD values were corrected for the basal EPL, which calculated the STTD percentage of P for each ingredient. The authors also determined the ATTD percentage of Ca. The following equations were used:

*P ATTD (%)* = $[(P_{intake} – P_{feces})/ P_{intake}] \times 100$

*Basal EPL (mg/kg of DMI)* = $([P_{feces}/ F_{intake}] \times 1000 \times 1000)$ where F = feed.

*STTD (%)* = $[P_{intake} – (P_{feces} – \text{basal EPL})/ P_{intake}] \times 100$; *Ca ATTD (%)* = $[(Ca_{intake} – Ca_{feces})/ Ca_{intake}] \times 100$

**Findings:**

The authors found that Ca and P concentrations vary between MBM sources. An average percentage of 9.2 ± 2.0% was determined for the calcium concentrations. The range of calcium concentrations was between 5.09 and 11.03%. The average P concentration was 4.3 ± 0.8%, in a range between 2.59 to 5.26%. Incidentally, the Ca:P ratio in the MBM samples was relatively consistent at 1.97 to 2.05 (CV = 4.3%).

The daily feed intake and fecal output did not differ among the pigs fed the different MBM diets. Tables 1 and 2 show the specific values of P and Ca availability and digestability for each of the specific MBM sources.

Phosphorus concentrations in feces differed significantly among the MBM sources, ranging from 2.02 to 8.51%. Specifically, P intake and output differed among the MBM sources, ranging between 1.19 to 2.38 g/d (intake) and from 0.23 to 1.02 g/d (output). Significant ($P < 0.05$) differences were observed in the daily amount of P absorbed (0.96 to 1.58 g/d) among the MBM sources as expected. The daily basal EPL due to various treatments did not differ among the diets. The STTD of P (54.8 to 84.4%) differed ($P < 0.02$) among the MBM sources, with an average of 68.8 ± 9.3%).

Calcium concentrations in feces differed ($P < 0.01$) between MBM sources. The range was from 4.03 to 18.34%. The daily Ca intake and output were different between sources as well (2.39 to 4.46 g/d for intake and 0.44 and 2.08 g/d for output). The ATTD of Ca varied among MBM sources (53.0 to 81.0%, with an average of 63.9 ± 9.4%). The authors did not observe any differences in the amount of Ca absorbed among the pigs fed different MBM sources.

**Practical Applications:**

In this study, there was variability of the P and Ca concentrations between sources of MBM. Compared to the nutrient concentrations in protein and ether

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**Table 1.**

| Variation among eight sources of MBM | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Source | | | | | | | |
| **Criteria** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| Crude Protein, % | 52.2 | 51.2 | 57.2 | 52.1 | 51.7 | 51.2 | 45.7 | 54.2 |
| Ether Extract, % | 14.1 | 15.2 | 14.4 | 12.6 | 11.7 | 11.8 | 11.6 | 13.4 |
| Ash, % | 28.2 | 24.7 | 20.6 | 29.6 | 27.8 | 28.6 | 33.2 | 25.3 |
| Calcium, % | 9.69 | 7.12 | 5.09 | 10.42 | 8.86 | 9.63 | 11.03 | 8.30 |
| Phosphorus, % | 4.72 | 3.65 | 2.59 | 5.05 | 4.43 | 4.49 | 5.26 | 4.06 |
| Calcium:phosphorus ratio | 2.05 | 1.95 | 1.97 | 2.22 | 2.02 | 2.14 | 2.10 | 2.04 |

**Table 2.**

| ATTD of phosphorus and calcium and STTD of phosphorus for different sources of MBM | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Source | | | | | | | |
| **Criteria** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| Feed intake (dry matter), g/day | 530 | 503 | 483 | 508 | 519 | 527 | 489 | 513 |
| Fecal output (dry matter), g/day | 13.42 | 10.20 | 11.70 | 14.64 | 14.38 | 13.15 | 10.76 | 12.88 |
| ATTD of phosphorus, % | 61.6 | 73.5 | 80.1 | 70.2 | 63.8 | 52.1 | 58.6 | 67.1 |
| EPL *, mg/day | 56 | 54 | 51 | 54 | 55 | 56 | 52 | 55 |
| STTD of phosphorus, % | 64.0 | 76.9 | 84.4 | 72.6 | 66.6 | 54.8 | 61.0 | 69.8 |
| ATTD of calcium, % | 57.2 | 73.2 | 81.0 | 66.3 | 62.7 | 53.0 | 56.0 | 62.1 |
| * Basal EPL x daily dry matter intake | | | | | | | | |

extract, the levels of Ca and P were two to four times more variable. This means it is important to estimate the concentration of P and Ca in the sources of MBM. The authors suggest that simply relying on published average values of P and Ca concentrations in MBM may over- or underestimate the actual concentrations. In swine diets, MBM often serves as the source of dietary P and Ca and the variability in MBM sources could result in deficiency or excess of the two minerals. Accounting for the variability and predicting the nutrient concentration of various MBM sources is essential for effectively utilizing MBM in swine diets.

Phosphorus in MBM was found to be 70% as digestible as the phosphorus in monosodium phosphate, when current study values were compared with other studies (Petersen and Stein, 2006). In this study, the STTD of P in MBM was greater than the STTD of P in corn (26.4%) and in soybean meal (48.3 to 56.7%, Almeida and Stein, 2010; Kim and Stein, 2010). In this study, the STTD of P in MBM decreased as concentrations of ash, Ca, and P increased. The variability can be explained by the differences in the concentration of ash, Ca and P in the various MBM sources. This is important to be aware of since a greater proportion of bones in the rendered material would negatively affect P digestibility and because P concentrations are greater in bone tissue compared to soft tissue. The assumption is that the greater the concentration of P in MBM, the greater the proportion of bone in the product. This explains the reduction in P digestibility as P concentration increases.

Usually the dietary Ca requirement for pigs is ex-

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pressed on the basis of total Ca (NRC, 1998). Recent research has reported the ATTD of Ca in corn and soybean meal and in calcium carbonate (Bohlke et al., 2005; Stein et al., 2011). The ATTD for Ca in MBM (mean 63.9%) in this study was within the range of values reported for the ATTD of Ca in calcium carbonate (Stein et al., 2011). This is a logical finding since one component of bone is calcium carbonate. Like phosphorus, there is a negative relationship between the concentration of ash in MBM and the ATTD of Ca. The correlation between the ATTD of Ca and the STTD of P indicates MBM sources with more bone to soft tissue ratios (and therefore, greater ash concentration) have reduced Ca and P digestibility. This study not only showed what may negatively affect Ca and P digestibility, but that the same factors that positively affect P digestibility, positively affect the digestibility of Ca.

It is important to realize that the ATTD of Ca is less than 100% in most feed ingredients. Therefore, it may be more accurate to formulate diets based on digestible Ca instead of total Ca (Stein et al., 2011).

Phosphorus and calcium are key nutrients in swine diets and much attention is paid to the source of these nutrients. This research indicates there is a great deal of variability in the availability and digestibility of these nutrients in MBM. This is related to the concentration of bone ash in the MBM source. Higher ash concentrations were found with higher concentrations of P and Ca, which were determined to reduce nutrient digestibility in MBM sources. The equations developed by Sulabo and Stein (2013), to predict total phosphorus concentrations in MBM can be used to determine estimates of phosphorus and calcium digestibility (Goihl, 2013). These calculations will help industry professionals better formulate diets with more precise nutrient composition and effectively and efficiently continue to balance rising feed costs with available feed ingredients.

**Information for this article taken from:**


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