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# A value based approach to determine optimal phytase dose: A case study in turkey poults

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ABSTRACT

There is a recent trend to increase phytase dose from the traditional 500 FTU/kg to 750 or 1000 FTU/kg in poultry feed formulations, driven by high inorganic phosphorus prices and more bioefficacious phytases. This paper outlines a method for calculating optimum phytase dose, based on the replacement of inorganic phosphorus through the application of the marginal decision rule. In this 21 day digestibility study 768 male BUT 6 turkey poults were assigned to 8 treatments (6 replications/treatment): a negative control diet based on corn/soy, meeting the nutritional requirements of turkey poults except in phosphorus (0.26% ret P) and calcium (0.8%), 4 graded levels of phytase over the negative control (345, 690, 1035, 1380 FTU/kg), and 3 graded levels of supplemental MCP (0.6, 1.2, 1.8 g P/kg). Significance was determined using ANOVA and means separation for all parameters was achieved using Tukey's HSD. Bodyweight gain was maximised at the 1035 FTU/kg dose, with all levels of phytase supplementations significantly increasing BWG compared to the negative control ($P < 0.05$). Non-linear regression was conducted on ileal phosphorus digestibility, and optimum phytase dose was determined using the as the point where the incremental value of P release was equal to the incremental phytase cost, assuming the value of incremental P from phytase was equal to the value of the same amount of digestible P from an inorganic source. The optimum dose of phytase under typical 2014 US market price conditions was calculated to be 996 FTU/kg. At 996 FTU/kg, 100% of the potential value of inorganic P replacement was captured, compared to 70% of the value at 500 FTU/kg. Under different phytase and inorganic P price conditions, the optimum dose varied between 762 FTU/kg and 1231 FTU/kg. In conclusion, this study highlights a method that provides a rational justification for use of targeted phytase doses greater than 500 FTU/kg.



## 1. Introduction

The majority of phosphorus in cereal grains is bound in the form of phytate (Maga, 1982) which has poor biovailability to monogastrics. Therefore, microbial phytases are widely used in poultry feeds as a means of improving dietary P availability and reducing P excretion in manure (Amerah et al., 2014).

Phytase has traditionally been used in poultry diets at a fixed dose of 500 FTU/kg based on historic calculations of economic value. However, the price of inorganic phosphorus has increased drastically in the last 10 years and more efficient and

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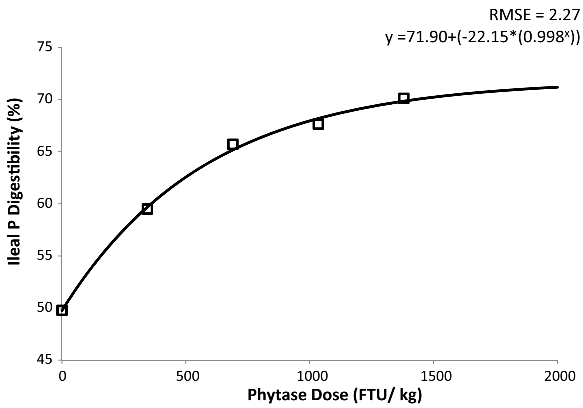


**Fig. 1.** Non-linear regression of ileal P digestibility (%) in response to an increasing dose of *Buttiauxella* phytase (FTU/ kg). FTU = phytase units.

economical phytases are available. More recently the concept of high phytase doses has attracted attention (Walk et al., 2014, 2013; Zeng et al., 2015, 2014); higher doses of phytase are believed to rapidly dephosphorylate the phytate molecule and maximise the alleviation of the anti-nutritional effects of phytate.

Furthermore, modern feed formulation software makes it feasible to adjust dose on a regular basis driven by the actual market price of feed ingredients. However, in most feed formulation databases, table values or values from suppliers are used to attribute the inorganic P (iP) contribution from phytase at a fixed dose (such as 500, 750 and 1000 FTU/kg). It is well known that with increasing phytase dose the iP release is not linear, as shown in Fig. 1, but rather follows a curvelinear pattern. In addition, the iP contribution is also related to the efficacy of the phytase *in vivo* and influenced by many other dietary and animal factors (Kornegay, 2001; Ravindran et al., 2000). Thus the optimum dose is susceptible to change, influenced by the price of phytase and phosphorus sources, and the efficacy with which the phytase liberates phosphorus from the diet. Using a feed formulation software with a table value on iP contribution may not realistically estimate the maximum potential in a specific condition.

In this study, a method was developed to calculate the optimal phytase dose to maximise economic benefit from inorganic P replacement based on P digestibility data generated from an *in vivo* trial in turkeys. The optimum dose to achieve the maximum benefit was determined by using the marginal decision rule – the point at which the cost of a unit of phytase is equal to the value of the phosphorus liberated by that unit (Barnard et al., 2015, 2014).

The aim of this study was to use a case study in turkey poults to demonstrate how to use the marginal decision rule to determine phytase dose at which the maximum economic benefit from inorganic phosphate replacement is achieved in turkeys.

## 2. Methods and materials

### 2.1. Animals, housing and diets

One-day old male BUT 6 turkey poults were purchased from the hatchery and during the five day pre-experimental period poults were housed in one large floor pen with wood shavings as a bedding material; water and a nutritionally adequate pelleted commercial starter diet were freely available.

At five days of age 768 healthy poults were assigned to 48 two-tier balance cages (16 birds per cage, six replicate cages per treatment) based on a weight class system in order to achieve similar bodyweights per cage at the start of the experiment.

Composition of the experimental diets is presented in Table 1. In order to ensure a consistent dietary composition across all treatments, a basal mixture of feed was produced containing 0.25% titanium dioxide as an inert dietary marker. Experimental diets were formulated without the inclusion of antimicrobial growth promoters or coccidiostats. All diets were analysed for moisture, ash, Ca, P and titanium (Ti).

The basal diet was formulated to meet the nutrient requirement of turkey poults based on the breeder's recommendation, except for P (0.26% ret P) and Ca (0.8%). Three positive controls were formulated by adding increasing levels of monocalcium phosphate (0.6, 1.2 and 1.8 g P from MCP); Ca content in the positive control diets was increased with 1.0 g/kg calcium to maintain suitable Ca:P ratios. The remaining basal mixture was then supplemented with a *Buttiauxella* sp. phytase (Axtra® PHY, Danisco Animal Nutrition, Marlborough, UK) in five graded doses. Based on the analysed phytase concentration per gram in the premix, it was calculated that the dosed levels were 345, 690, 1035 and 1380 FTU/kg diet. One FTU is defined as the quantity of enzyme that releases 1 μmol of inorganic P/min from 5.0 mM sodium phytate at pH 5.5 at 37 °C. Analysed phytase recovery in pelleted diets was within an acceptable range (±15% target dose) in all treatment groups therefore targeted dose was used in the modelling.

Water and the experimental diets were available to the birds *ab libitum* from 5 to 21 days of age.

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