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Effect of increasing *Buttiauxella* phytase dose on nutrient digestibility and performance in weaned piglets fed corn or wheat based diets

Y. Dersjant-Li[a,*], A.L. Wealleans[a], L.P. Barnard[a], S. Lane[b]

[a] Danisco Animal Nutrition, DuPont Industrial Biosciences, Marlborough, UK
[b] Drayton Animal Health, Alcester Road, Stratford-upon-Avon, Warwickshire, CV37 9RQ, UK

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ABSTRACT

Two experiments were carried out to determine the effect of increasing phytase levels on apparent total tract digestibility (ATTD) of nutrients, P and Ca retention and growth performance in weaned piglets fed corn or wheat based diets. Five treatments were tested including a positive control (PC) meeting piglet nutrient requirements; a negative control (NC) formulated with a reduction in digestible P (−1.4 g/kg and −1.5 g/kg in Exp. 1 and 2 respectively) and Ca (−1.5 g/kg in both studies); and NC supplemented with a *Buttiauxella* phytase at 500, 1000 or 2000 phytase units (**FTU**)/kg feed. One FTU is defined as the amount of enzyme required to release 1 μmol of iP (inorganic phosphorus) per minute from sodium phytate at pH 5.5 at 37 °C. A complete randomized design was used in both studies, with individual piglets housed in metabolic crates as the experimental unit. There were 2 runs in Exp. 1 and 4 runs in Exp. 2. Each treatment consisted of 8 replicates (1 piglet/replicate) in Exp. 1 and 12 replicates in Exp. 2. Diets based on wheat and soybean meal in Exp. 1 and corn and soybean meal in Exp. 2 were fed in pelleted form; feed and water were supplied *ad libitum* to the piglets (mean initial BW of 11 ± 1.5 kg) during the 14 day period. Urine and feces production were collected from each crate during d 10 to14. The ATTD of P, Ca, DM, N and energy, and retention of P and Ca were measured using TiO_2 as an indirect marker. In both Exp, increasing phytase dose from 0 (NC) to 2000 FTU/kg linearly increased ($P < 0.05$) ADG and G:F. Phytase at 2000 FTU/kg improved ADG and G:F compared to NC. A linear response was seen for ATTD of P, Ca and GE ($P < 0.05$) in Exp. 1, and for ATTD P and Ca in Exp. 2, with increasing phytase dose. Also there was a tendency for increasing phytase dose to result in a linear increase ($P \leq 0.10$) in ATTD of DM in Exp.1, and ATTD of DM and N in Exp. 2. Increasing phytase dose linearly reduced P and Ca excretion and increased the retention of these nutrients in both experiments. The results showed that increasing *Buttiauxella* phytase dose up to 2000 FTU/kg may provide environmental and production benefits in weaned piglets fed either wheat or corn based diets.

1. Introduction

Phosphorus in plant based ingredients is mainly present in the form of phytate (up to 80% of total P), which has limited availability to monogastric animals. Phytate (the salt form of phytic acid, inositol-6-phosphate, IP6) can bind to protein and minerals

Abbreviations: ATTD, apparent total tract digestibility; Ca, calcium; FTU, phytase units; G:F, gain/feed; N, nitrogen; P, phosphorus

* Corresponding author at: Nisco Animal Nutrition DuPont Industrial Biosciences Danisco UK Ltd P.O., UK.
E-mail address: Yueming.Dersjant-Li@Dupont.com (Y. Dersjant-Li).

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as well as interact with endogenous enzymes, thus reducing nutrient utilization (Selle et al., 2012). Phytase has traditionally been used in pig feed at 500 phytase units (FTU)/kg based on historic calculations of economic value. However, the price of inorganic phosphorus (iP) has increased drastically in the last 10 years and more efficient and economical phytases are available in the market. Furthermore, it is recognized that phytase can reduce the anti-nutritional effect of phytate, improve nutrient digestibility such as amino acids, therefore resulting in extra-phosphoric effect (Adedokun et al., 2015; Cowieson et al., 2008; Selle et al., 2012). In grower pigs, increasing phytase dose from 250 to 1000 FTU/kg resulted in a linear increase in ADG (Dersjant-Li et al., 2017), phytase dosed at 1000 FTU/kg improved ADG by 5.3% vs a positive control. All these factors have led to the use of higher doses of phytase in swine diets.

The primary function of phytase is to degrade phytate and to improve P digestibility. However, using the traditional dose of 500 FTU/kg, *in vivo* phytate hydrolysis is incomplete. A review of the literature by Dersjant-Li et al. (2015) showed that approximately 45–60% of phytate was degraded, by the end of the small intestine, in diets containing phytase at 500 FTU/kg, and between 55 and 88% in diets containing 1000 FTU/kg. The phytate degradation rate was related to phytase source, dose, dietary Ca and available P levels, phytate level and grain source.

A high dose (> 1000 FTU/kg) of a bio-efficacious phytase will degrade phytate more thoroughly in the stomach and in the upper part of the small intestine, more effectively eliminating the anti-nutritional effect of phytate and resulting in increased nutrient digestibility and growth performance in piglets. The response of piglets to increasing phytase dose may be related to dietary grain source and phytate levels. The objective of this paper was to evaluate the effects of a *Buttiauxella* phytase at a dose range of 0–2000 FTU/kg on nutrient digestibility, retention and performance in weaned piglets fed wheat- or corn-based diets using data from two studies.

2. Materials and methods

Two digestibility studies were carried out to test the effects of increasing phytase dose on nutrient digestibility and performance in weaned piglets. Both studies were carried out at Drayton, Stratford upon Avon, UK and approved by Animal Welfare committee.

2.1. Animals

Two studies were carried out using weaned piglets individually housed in metabolic crates in an environmentally controlled facility. Lighting was set at 16:8 h light: dark and temperature was set to gradually reduce from 27 to 23 °C over the course of the experiment. In Exp. 1 a total of 40 weaned entire male Large White x Landrace piglets with initial age between 28 and 32 days were used. The study was completed in 2 runs, with 4 replicates/treatment in each run, 8 replications per treatment. In Exp. 2, a total of 60 entire male Landrace x Duroc piglets aged between 21 and 28 days were used; 15 piglets/run in 4 runs, with 1 piglet/crate and 3 piglets/treatment in each run, 12 replications per treatment. In both trials, after a 7d acclimatization period (on a commercial diet) piglets were randomly allocated to metabolic crates with an average initial BW of 11 ± 1.5 kg.

2.2. Experimental design

The treatments included a positive control (PC) diet formulated to meet the nutrient requirements of the piglets; a negative control (NC) with a reduction in digestible P and Ca; and NC diet supplemented with a 6-phytase from *Buttiauxella* sp. (Danisco Animal Nutrition, DuPont Industrial Biosciences, Marlborough, UK) at 500, 1000 or 2000 FTU/kg respectively. One FTU is defined as the quantity of enzyme that releases 1 μmol of inorganic P per minute from 5.0 mM sodium phytate at pH 5.5 at 37 °C (AOAC, 2000). Negative control diets were formulated with 1.5 g/kg lower Ca in both trials and with 1.4 g/kg and 1.5 g/kg lower digestible P in Exp. 1 and 2 respectively compared to PC. However, the analyzed total P content was 1.7 g/kg and 2.4 g/kg lower in NC compared to PC, for Exp. 1 and 2 respectively (Table 1).

2.3. Experimental diets

In Exp. 1 a wheat and soybean meal based diet was used and in Exp. 2, a corn and soybean meal based diet was used. The composition of PC and NC diets is summarized in Table 1. One batch of NC diet was produced and split into 4 batches before phytase was added to the treatment batches. Diets were fed in pelleted form (pelleting temperature < 80 °C); feed and water were provided *ad libitum* throughout the 14d period. Animals were weighed at the start and the end of each run. The amount of feed offered to each crate was measured daily and any feed wasted or removed was weighed to provide a total feed intake during the study. Feed samples were analyzed for phytase activity and phytic acid content by Danisco Innovation Laboratories (Brabrand, Denmark), using the method described by Yu et al. (2012, 2014).

2.4. Sampling and measurements

Average daily feed intake, ADG and G:F were calculated for each piglet. Total collection of feces and urine was conducted during days 10–14; urine and fecal productions were recorded twice daily for each of the crates for each run. Fresh feces were collected from each crate at least twice daily and refrigerated at approximately 4 °C. At the end of the collection period the total 4 day collection for each animal was weighed. After thorough mixing and homogenization a sample from each animal was weighed and dried at 55 °C to