Influence of supplemental phytase on growth performance, digestion and phosphorus balance in lambs fed sorghum-based diets

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Abstract

Phosphorus excretion in lambs from urine and faeces is considerably high due to elevated concentration of grains in the diets. This study evaluated the effect of supplemental phytase on in vitro dry matter degradation (IVDMD), feed intake, growth performance, total tract digestion and phosphorus (P) balance in finishing lambs fed sorghum-based diets. An exogenous phytase mixture was added at dosage of 0, 750, 1500 and 2250 FTU (phytase units) per kg diet as fed. Thirty-two finishing lambs (21.5±2.2 kg body weight) were randomly assigned to those diets and fed for 60 d. The P concentration in the diets varied between 2.0 to 2.4 mg/kg dry matter (DM). Inclusion of phytase in the diet had no effect on IVDMD. However, total tract digestion of DM, NDF and P were linearly (P<0.01) improved as phytase level supplementation increased. Phosphorus intake and excretion (urine and faeces) were not affected (P>0.05) by phytase, but P retention showed a linear increment as the enzyme increased in the diet. Growth performance of lambs was not affected by phytase. Therefore, phytase supplementation improved P digestion and retention, but it did not change P excretion and growth performance in finishing lambs fed sorghum-based diets.

Materials and methods

Four sorghum-based diets were formulated for finishing lambs according to NRC (1985). Phytase (Natuphos 5000G, BASF Mexicana, México City, México) was added at 0, 750, 1500 and 2250 FTU (phytase units) per kg diet as fed. According to the manufacturer, the phytase would be supplemented at 1000 to 2000 FTU/kg DM. The enzyme was produced by Aspergillus niger with a phytase activity of 5000 FTU/g. Diets were chemically analyzed to determine dry matter (DM), crude protein (CP), ash (AOAC, 1995), neutral detergent fiber (NDF) and acid detergent fiber (ADF; Van Soest et al., 1991) and P concentration (Fiske and Subbarow, 1925).

A first study to evaluate the influence of phytase supplementation in diets for finishing lambs on IVDMD was performed using the first phase of Tilley and Terry procedure (1963). Ruminal fluid was collected from two sheep fitted with ruminal cannula and fed with the sorghum-base diet. Diet samples were ground to pass through a 1 mm screen and oven dry at 60°C for 24 h. Feed samples (500 mg DM) were placed into crystal tubes and incubated with a McDougall saliva and ruminal fluid mixture (4:1) at 3, 6, 12, 24 and 48 h. Before in vitro incubation, feed samples, McDougall saliva and ruminal fluid were mixed for 5 min to estimate the soluble fraction. Residual samples were recovered with filter paper (Whatman 541). The IVDMD was analyzed using a Gompertz model according to Susmel et al. (1999). The DM remaining at each incubation time was used to fit a non-linear regression model using the “NLIN” option of SAS (1999). In vitro degradation kinetic data were analyzed as a completely randomized design with 3 tubes per time per treatment. Orthogonal polynomials were used to test effects of phytase level supplementation on in vitro dry matter degradation.

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To evaluate the influence of phytase supplementation on total tract digestion, P balance and growth performance in finishing lambs, sorghum diets were randomly assigned to 32 crossbreed (Suffolk x Creole) male lambs (21.5±2.2 kg body weight) housed in individual metabolic pens in a naturally ventilated barn. Sorghum-base diet (expressed as dry matter) was 700 g sorghum, 100 g molasses, 90 g corn stover, 90 g oat straw and 20 g urea. Lambs had free access to diet (fed at 07:00 and 16:00 h) ensuring orts of 1% of the amount fed daily, as well as to water. The experiment lasted 60 d plus 15 d of adaptation. Each two weeks (15, 30, 45 and 60 d) body weight (BW) was registered; feed intake was recorded daily and averaged each two weeks. Refusals plus wastage were used to calculate DM intake. Three days before 15, 30, 45 and 60 d faeces and urine were collected (100%) and sampled (10%). Samples of feed offered and feed
Results

Table 1. Influence of phytase supplementation on in vitro dry matter degradation (IVDMD), total tract digestion, P balance, and growth performance of finishing lambs fed sorghum-based diets.

| Phytase (phytase units/kg as fed) | 0 | 750 | 1500 | 2250 | SEM |
|----------------------------------|---|-----|------|------|-----|
| **Phosphorus** L                 | 37.3 | 40.5 | 42.3 | 49.5 | 3.9 |
| **Neutral detergent fibre** L     | 527 | 552 | 564 | 624 | 4.5 |
| **Soluble fraction** L            | 189 | 172 | 178 | 178 | 7.9 |
| **Potentially degradation** L     | 520 | 517 | 519 | 507 | 24.6 |
| **Total degradation a + b** L     | 709 | 689 | 697 | 685 | 31.2 |
| **Degradation rate c, /h** L      | 95  | 97  | 96  | 95  | 6.9 |
| **Total tract digestion, g/kg DM** | 741 | 769 | 773 | 799 | 4.6 |

Discussion

Phosphorus concentration in diets averaged 2.2 g/kg DM. According to the NRC (1985), the P requirements for finishing lambs range between 1.9 to 2.4 g/kg DM, which were calculated according to total endogenous losses of 30 mg/kg. There are few analyses about P recommendations for finishing lambs, but Erickson et al. (1999, 2002) indicated that 1.4 to 1.6 g/kg DM are enough to meet those requirements. Therefore, P concentrations in the diets matched to those from NRC (1985), but were higher than the values reported by Erickson et al. (1999, 2002). However, our results confirm that, for finishing lambs, the addition of P supplement to sorghum-based diets is an unnecessary economic cost, in addition to a negative impact on the environment.

Phytase did not modify in vitro kinetics characteristics of diets, which may be due to the fact that in vitro procedures did not associate with dynamic microbial populations, microbial buffer capacity, intake, as well as ruminal and intestinal flows. Therefore, physical properties of the diet and ruminal passage rates may represent advantages to prevent hydrolysis of phytate in the rumen (Sauvant et al., 1999), as compared to in vitro conditions. Our results indicate that exogenous phytase improved total tract P digestion, which could enhance P retention. Kincaid et al. (2005) found that P digestibility of high grain diets was increased by phytase supplementation due to a synergism with phytase-producing bacteria, which are starch-fermenting organisms (Knowlton et al., 2007). Therefore, P availability could be increased by phytase, and then enhance enzyme systems of ruminal microor-

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ganisms and fermentation of structural carbohydrates (Durand and Komisarczuk, 1988), such as that found on total tract digestion of NDF. In fact, high-grain diets (70%) and low pH induces disturbances in P excretion (Harmon and Britton, 1983) reducing native phytase activity (Godoy and Meschy, 2000). Phytase supplementation improved P digestion and retention, but it was not enough to change P excretion and serum levels as was reported by Knowlton et al. (2007). Our finding could be due to the fact that P concentrations in the diets did not exceed recommendation levels. Besides, significant amounts of P are incorporated by the rumen microbial population as a component of their nucleic acids and phospholipids (Iqbal et al., 2005). Furthermore, ruminants have higher P amount in the saliva than is required to maintain normal concentrations in body pools. Therefore, the salivary phosphorus can regulate P variations due to diet (Clark et al., 1973), which would explain the non-significant effects of phytase supplementation on P plasma and P excretion.

Conclusions

Exogenous phytase increased DM, NDF and P digestion, as well P retention in finishing lambs fed sorghum based diets, but it was not enough to reduce the P excretion and enhance growth performance in those lambs.

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