Animal Feed Science and Technology 214 (2016) 95–103

Contents lists available at ScienceDirect

Animal Feed Science and Technology

journal homepage: www.elsevier.com/locate/anifeedsci

A comparison of the nutritional value of organic-acid preserved corn and heat-dried corn for pigs

X. Xu [a], H.L. Wang [a], P. Li [a], Z.K. Zeng [a], Q.Y. Tian [a], X.S. Piao [a,*], E.Y.W. Kuang [b]

[a] State Key Laboratory of Animal Nutrition, Ministry of Agriculture Feed Industry Centre, China Agricultural University, Beijing 100193, China

[b] Kemira (Asia) Company Limited, Shanghai 200233, China

ARTICLE INFO

Article history:
Received 14 May 2015
Received in revised form 11 February 2016
Accepted 21 February 2016

Keywords:
Amino acid digestibility
Corn
Energy content
Organic-acid preservation
Performance
Piglets

ABSTRACT

Three experiments were conducted to compare the digestible (DE) and metabolizable energy (ME) content (Exp. 1), as well as the apparent (AID) and standardized (SID) ileal digestibility of amino acids (AA) (Exp. 2) in organic-acid preserved and heat-dried corn. In addition, the performance of weanling pigs fed diets containing the two corns was compared (Exp. 3). In Exp. 1, 12 growing barrows (28.5 ± 1.50 kg) were randomly allotted to 1 of 2 groups and fed diets containing 970 g/kg organic-acid treated or heat-dried corn to determine the DE and ME content of the two differently processed corns. The results indicated that the DE and ME of organic-acid treated corn were 16.6 and 16.3 MJ/kg, which was greater than the 16.4 and 15.9 MJ/kg, for the DE and ME of heat-dried corn ($P < 0.05$ and $P < 0.01$). In Exp. 2, 18 growing barrows (27.6 ± 4.38 kg), fitted with a T-cannula in the distal ileum, were allotted to be fed 1 of 3 semi-synthetic diets with 6 pigs per treatment. Two of the 3 diets were of similar composition to those used in Exp. 1 while the 3rd was a nitrogen-free diet that was used to measure basal endogenous losses of CP and AA. The results from Exp. 2 showed no significant difference in the AID or SID of CP and AA between the 2 corns. In Exp. 3, 60 piglets, weaned at 28 day (7.34 ± 1.243 kg), were randomly allotted to 1 of 2 complete diets with 5 pigs per pen and 6 pens per dietary treatment for 4 weeks. Piglets fed organic-acid treated corn had 10.5% greater average daily gain (389 g/day) than pigs fed heat-dried corn (352 g/day; $P < 0.05$). Feeding organic-acid treated corn significantly increased average daily feed intake by 12.5% (604 vs. 539 g/day) compared with heat-dried corn ($P < 0.05$). In conclusion, the available energy content of organic-acid treated corn was greater than heat-dried corn, and organic-acid treated corn improved weanling pig performance.

1. Introduction

Corn is widely used in swine feeds as an energy source and the quality of corn has been shown to affect pig performance (Linneen et al., 2008). However, molds in corn are becoming a serious problem (Williams et al., 2004). Corn production techniques have been rapidly improved aiming to utilize corn more efficiently. Drying is a natural and efficient process in

Abbreviations: ME, metabolizable energy; DE, digestible energy; ADFI, average daily feed intake; ADG, average daily gain; BW, body weight; AA, amino acid; CP, crude protein; AID, apparent ileal digestible; SID, standard ileal digestible.

* Corresponding author. Fax: +86 1062733688.
E-mail address: piaoxsh@mafic.ac.cn (X.S. Piao).

http://dx.doi.org/10.1016/j.anifeedsci.2016.02.016
0377-8401/

many areas and it can prevent mold. In most areas, corn can be dried after harvest, but this technique requires a high energy input. Therefore, it will be beneficial if a better way to preserve corn can be identified.

Many reports have shown that organic acids such as formic acid, propionic acid, formate and propionate sprayed onto corn can prevent mold and improve livestock performance (Young et al., 1970; Tsiloyiannis et al., 2001a, 2001b; Luan et al., 2013). Although the results of many experiments have indicated that organic acids used as a feed additive (i.e., directly incorporated into the feed) may benefit intestinal health (Dibner and Buttin 2002; Hansen et al., 2007; Garcia et al., 2007), it is not known if spraying organic acids onto corn during processing has the same effect. Therefore, this study was conducted to test the hypothesis that the DE and ME as well as the apparent ileal (AID) and standardized ileal (SID) digestibility of organic-acid preserved corn is greater than heat-dried corn. The second hypothesis was that pigs fed diets containing organic-acid treated corn will have improved performance compared with pigs fed diets containing heat-dried corn.

2. Materials and methods

2.1. General

The organic-acid treated and heat-dried corn were produced from the same source (moisture = 186 g/kg, before processing). One batch of the corn grain was processed by spraying organic-acids (composition: formic acid = 568 g/kg, propionic acid = 177 g/kg, ammonium salt = 52 g/kg, sodium salt = 28 g/kg, moisture = 175 g/kg; dosage rate 7 kg/t corn) onto the corn. The organic-acid was sprayed onto the corn after the corn was threshed. A second batch of the corn was dried by heating using a concurrent–countercurrent flow-type grain dryer (TDH300, Jinghua, Henan, China). The corn was dried with a concurrent flow hot air in three stages: (1) 140 °C for 2 h, (2) 110 °C for 1 h and (3) 70 °C for 1 h followed by a countercurrent flow cooling period of 2 h. At the end of the drying process, the moisture content of the corn had dropped to 140 g/kg. During these steps, the grain temperature did not exceed 50 °C thus avoiding a reduction in the quality of the corn (Huang et al., 2015). After treatments, both batches of corn were placed in the same store room (Ministry of Agriculture Feed Industry Centre, Beijing, China) under natural conditions for 7 months (the temperature and humidity of the room averaged 20 °C and 50%). The chemical content and mycotoxin levels of the two corns are shown in Table 1.

The protocols used in these experiments were approved by the China Agricultural University Institutional Animal Care and Use Committee (Beijing, China). All experiments were conducted at China Agriculture University Animal Experiment Base (Fengning, China).

2.2. Animals and experimental design

All pigs were Duroc × Landrace × Large White crossbreds. In Exp. 1 and 2, the pigs were individually housed in $1.2 \times 0.7 \times 0.9\ m^3$ stainless steel metabolism cages located in an environmentally controlled room (daily range from 20 to 24 °C). In Exp. 3, 60 weanling pigs were housed in twelve $1.8 \times 1.2\ m^2$ with 5 pigs per pen. The pens had half solid and half slatted floors.

2.3. Exp. 1

Exp. 1 was conducted to determine the DE and ME of the two of corns. Twelve barrows (28.5 ± 1.50 kg) were assigned to 1 of 2 experimental treatments. The experimental diets consisted of 970 g/kg organic-acid treated or heat-dried corn supplemented with minerals and vitamins (Table 2). The diets were provided at a rate of 40 g/kg of BW determined at the initiation of the adaptation period. The daily feed allowance was divided into two equal sized meals fed at 08:00 and 16:00 h. Water was freely available from a low-pressure drinking nipple. The diets were provided in mash form.

After an adaptation period of 7 days, a total collection of faeces and urine was conducted for 5 successive days following the methods described by Li et al. (2015). The feed intake of pigs was recorded daily. Feed refusals and spillage were collected daily and analyzed for DM. Faeces were collected immediately as they appeared in the metabolism crates and placed in plastic bags to be stored at −20 °C. Urine was collected in a bucket placed under the metabolic crate. The buckets contained 10 mL of 6*N* HCl for every 1000 mL of urine. Every day, the total urine volume was measured and a 100 mL aliquot from every 1000 mL of urine was filtered through gauze and 50 mL of the mixed urine samples were transferred into a screw-capped tube and immediately stored at −20 °C until needed for analysis. At the end of the collection period, faeces were thawed, pooled by pig, homogenized, sub-sampled, dried for 72 h in a 65 °C drying oven and ground through a 1-mm screen. Likewise, all stored urine samples were mixed and homogenized for each pig.

2.3.1. Exp. 2

Exp. 2 was designed to determine the AID and SID of CP and AA in the 2 batches of corn. Eighteen barrows (27.6 ± 4.38 kg) were surgically fitted with a T-cannula in the distal ileum using procedures adapted from Stein et al. (1998). Before surgery, barrows were fasted for 24 h. The post-operative period was 14 d during which time a balanced diet was provided to allow ad libitum intake to the pigs. The barrows were assigned to 1 of 3 treatments. Two of the experimental diets were formulated to be similar to those used in Exp. 1 (Table 2). In addition, a nitrogen-free diet was used to estimate basal endogenous losses (IAA_{end}) of CP and AA. All diets contained 2.5 g/kg chromic oxide as an indigestible marker.