Animal Feed Science and Technology 197 (2014) 176–184

Contents lists available at ScienceDirect

Animal Feed Science and Technology

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

# Effects of maize conservation techniques on the apparent total tract nutrient and mineral digestibility and microbial metabolites in the faeces of growing pigs

E. Humer, W. Wetscherek, C. Schwarz, K. Schedle*

*Institute of Animal Nutrition, Products and Nutrition Physiology, Department for Agrobiotechnology, University of Natural Resources and Life Sciences Vienna, Muthgasse 11, A-1190 Vienna, Austria*

ARTICLE INFO

*Article history:*
Received 28 February 2014
Received in revised form 16 August 2014
Accepted 20 August 2014

*Keywords:*
Maize
Digestibility
Fermentation
Microbial metabolites
Phytate
Pig

ABSTRACT

A digestibility trial was conducted to investigate the effects of different maize conservation techniques on the nutrient digestibility of a commercial maize–soybean meal diet fed to growing pigs. The influence on the content of biogenic amines, volatile fatty acids (VFAs) and ammonia in the faeces was also determined. Maize was either dried (dried maize), ensiled after milling (maize silage) or tight-closed-stored (TCS-maize) as a whole grain. Nine growing pigs (35.1 ± 0.8 kg) were used in a 3 × 3 Latin square experiment. They were fed diets based on the different maize conserves, barley and soybean meal to ensure the same content of N, energy and digestible phosphorus (P) in the diet. The apparent total tract digestibility (ATTD) of the DM, ash and starch was improved ($P<0.05$), and the ATTD of the ether extract tended to be improved ($P<0.10$) when the maize was fermented. Moreover, based on the results related to the ATTD of P in the different maize conserves of a previous study, less P was added to diets that were based on fermented maize. Nevertheless, the P excretion was reduced without compromising P utilisation. The metabolic products of the gut microorganisms, biogenic amines and most VFAs in the faeces were reduced when the animals were fed fermented maize ($P<0.05$). The observed effects were more pronounced in the maize silage treatment. In conclusion, the current data suggest that the air-proofed storage of wet maize can be a strategy to improve the feeding value of maize-based diets fed to pigs.



## 1. Introduction

In recent years, increasing attention has been focused on the fermentation of feed for pigs. In addition to the objective of feed conservation, this technology can be a strategy to improve nutrient digestibility (Sholly et al., 2011; Kraler et al., 2014). The impact of fermentation on the content of antinutritional compounds, such as phytates, trypsin inhibitors, saponins or tannins, has also been reported (Canibe and Jensen, 2012). Moreover, a high-quality fermentation process can reduce the

*Abbreviations:* AA, amino acids; AID, apparent ileal digestibility; ATTD, apparent total tract digestibility; BW, body weight; CF, crude fiber; CP, crude protein; DM, dry matter; EE, ether extract; GE, gross energy; InsP, inositol phosphates; ME, metabolisable energy; OM, organic matter; TCS-maize, tight-closed-stored maize; VFA, volatile fatty acids.

* Corresponding author. Tel.: +43 1 47654 6108; fax: +43 1 47654 6105.
*E-mail address:* karl.schedle@boku.ac.at (K. Schedle).

http://dx.doi.org/10.1016/j.anifeedsci.2014.08.006
0377-8401/

feed pH as well as the gastrointestinal pH, and it may activate naturally occurring enzymes and improve gut health (Canibe and Jensen, 2003; Carlson and Poulsen, 2003).

Maize is one of the most important feed ingredients in swine diets. In some regions of Europe, storage of maize in a wet form is used to reduce drying costs, so the feeding of fermented maize is widespread in pig production. In addition to the fermentation of ground maize (maize silage), maize ensiling as whole grain (TCS-maize) is also well established. Hence, differences in fermentation characteristics have arisen. Fermentation can be a strategy to improve the digestibility of nutrients, but this issue has scarcely been investigated. In a previous study, we investigated the effect of three maize conservation techniques (dried maize, maize silage, and TCS-maize) on the ATTD of P, Ca, ash, dry matter (DM), organic matter (OM) and crude protein (CP) in pigs (Humer et al., 2013). The results showed an increased ATTD of P, Ca and ash through maize fermentation. The ATTD of DM and OM were not influenced by fermentation, whereas the ATTD of CP was lower in the fermented maize compared to the dried maize, and this effect was more pronounced in the maize silage. Based on these results and a nutrient analysis of the different maize conserves prior to feed preparation, practical maize–soybean meal diets that were balanced in N, energy and digestible P content were formulated and used to test the following hypotheses: fermentation of maize in the form of maize silage and tight-closed-stored maize (TCS-maize) as a main feed component in a commercial diet for growing pigs improves the ATTD of the nutrients in the pigs' diets. Furthermore, feeding pigs a diet with fermented maize as the main feed component requires less P supplementation compared to diets with dried maize and does not impair P retention.

## 2. Materials and methods

### 2.1. Maize conservation and diet formulation

The maize that was used (P9569, Pioneer, Parndorf, Austria) was dried (dried maize), ground with a hammer mill with a 3.5 mm screen and then ensiled (maize silage) or tight-closed-stored as whole grain (TCS-maize). The maize temperature did not exceed 55 °C during the drying process. Maize silage was prepared by the air-tight storage of milled maize under standardised conditions (grinding, compressing, and air-tight closing) in air-tight 6 L wide-neck kegs (Bär, Salzburg, Austria). In contrast, the TCS-maize was kept air-tight in the same kegs as the whole grain. The fermented maize was stored for 16 weeks before the experiment started. The diets were formulated according to the recommendations of GfE (2006) and based on a nutrient analysis of the conserves prior to feed preparation to ensure that they were isonitrogenous as well as isocaloric test diets. The diets consisted of the differently conserved maize, barley and soybean meal along with an AA-, mineral- and vitamin-premix. The ingredient composition of the diets is shown in Table 2. According to certain differences in CP- and AA-contents between the maize conserves, small variations in the contents of the soybean meal (increased contents in the maize silage and TCS-maize treatments) and AAs occurred in the test diets to ensure equal concentrations of CP and essential AAs. As described above, calculations for the supplementations of inorganic P were based on the preceding study in which a higher ATTD of P was obtained when the maize was fermented (Humer et al., 2013). Therefore, less monocalciumphosphate had to be supplemented in the maize silage and TCS-maize group. Before feeding, the maize and TCS-maize were briefly ground with a conventional mill to pass through a 3.5 mm screen.

### 2.2. Animals and housing

The protocol of the pig study was approved by the Austrian Ministry for Science and Research and by the University of Natural Resources and Life Sciences, Vienna (BMWF-66.016/0010-II/3b/2011). The experiment was conducted following a $3 \times 3$ Latin square design at the SRC (Lichtenwörth, Austria) with 9 crossbred barrows, which were progeny of (Duroc × Landrace) × Piétrain. The animals were allotted randomly according to body weight (BW) ($35.1 \pm 0.8$ kg) and litter (pigs from 3 different litters were used) to individual metabolic cages (Ehret, Tulln, Austria). The experiment started with a 7-day adaptation period to the metabolism cages where a commercial diet for growing pigs that was based on maize and soybean meal was fed *ad libitum*. Each experimental period consisted of 12 days, with 7 days of diet adaptation and 5 days of sampling period. The stainless steel cages were equipped with wire mesh screens and drain pans for the separate collection of faeces and urine. The cage size was adjusted to the body size of each individual animal during the feeding trial.

The barrows were fed equal amounts twice daily at 7 AM and 6 PM. The feed intake was limited to 2.5 times of the metabolisable energy (ME) requirements for maintenance (GfE, 2006), which were based on the average BW of the pigs at the start of each experimental period. The pigs had free access to water throughout the whole experiment, and their faeces were collected quantitatively and stored at −20 °C to prevent microbial activity. To avoid N volatilisation, 10 ml (25%, vol/vol) of sulphuric acid was added to the container for urine collection daily, and a solution (2%, vol/vol) of sulphuric acid was applied to the connecting funnel twice daily. The total amount of urine was weighed, and aliquots were collected and immediately frozen and stored at −20 °C. At the end of each experimental period, the faeces and urine samples were thawed, pooled for each animal, and a subsample was retained for further analysis.