Animal Feed Science and Technology 209 (2015) 128–136

Contents lists available at ScienceDirect

Animal Feed Science and Technology

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

Effects of nutrition on digestion efficiency and gaseous emissions from slurry in growing pigs: III. Influence of varying the dietary level of calcium soap of palm fatty acids distillate with or without orange pulp supplementation

W. Antezana[a,b], S. Calvet[a], A. Beccaccia[c], P. Ferrer[a], C. De Blas[c], P. García-Rebollar[c,*], A. Cerisuelo[d]

[a] Instituto de Ciencia y Tecnología Animal, Universitat Politècnica de València, Camino de Vera s/n, 46022 Valencia, Spain
[b] Facultad de Agronomía y Zootecnia, Universidad Nacional de San Antonio Abad del Cusco, Av. de La Cultura 733, P.B. 921, Cusco, Perú
[c] Departamento de Producción Agraria, Universidad Politécnica de Madrid, E.T.S. Ingenieros Agrónomos de Madrid, Ciudad Universitaria s/n, 28040 Madrid, Spain
[d] Centro de Investigación y Tecnología Animal, Instituto Valenciano de Investigaciones Agrarias, Pol. La Esperanza 100, 12400 Segorbe, Castellón, Spain

ARTICLE INFO

Article history:
Received 21 January 2015
Received in revised form 14 July 2015
Accepted 19 July 2015

Keywords:
Ammonia emission
Calcium soap of palm fatty acids
Digestion efficiency
Growing pigs
Methane emission
Orange pulp
Slurry

ABSTRACT

The aim of this study was to establish the relationships between faecal fat concentration and gaseous emissions from pig slurry. Five diets were designed to meet essential nutrient requirements: a control and four experimental feeds including two levels (35 or 70 g/kg) of calcium soap fatty acids distillate (CSP) and 0 or 200 g/kg of orange pulp (OP) combined in a 2 × 2 factorial structure. Thirty growing pigs (six per treatment) were used to measure dry matter (DM) and N balance, coefficients of total tract apparent digestibility (CTTAD) of nutrients, faecal and urine composition and potential emissions of ammonia (NH_3) and methane (CH_4). Increasing dietary CSP level decreased DM, ether extract (EE) and crude protein (CP) CTTAD (by 4.0, 11.1 and 3.5%, respectively, $P<0.05$), but did not influence those of fibrous constituents. It also led to a decrease (from 475 to 412 g/kg DM, $P<0.001$) of faecal concentration of neutral detergent fibre (aNDFom) and to an increment (from 138 to 204 g/kg, $P<0.001$) of EE in faecal DM that was related to greater CH_4 emissions, both per gram of organic matter ($P=0.021$) or on a daily basis ($P<0.001$). Level of CSP did not affect N content in faeces or urine, but increased daily DM ($P<0.001$), and N ($P=0.031$) faecal excretion with no effect on urine N excretion. This resulted in lesser ($P=0.036$) NH_3 potential emission per kg of slurry. Addition of OP decreased CTTAD of EE (by 7.9%, $P=0.044$), but increased ($P<0.05$) that of all the fibrous fractions. As a consequence, faecal EE content increased (from 165 to 177 g/kg DM; $P=0.012$), and aNDFom decreased greatly (from 483 to 404 g/kg DM, $P<0.001$), which in all resulted in a lack of effect of OP on CH_4 potential emission. Inclusion of OP in the diet also led to a significant decrease of CP CTTAD (by 6.85%, $P<0.001$), and to an increase of faecal CP concentration (from 174 to 226 g/kg DM,

Abbreviations: ADFom, acid detergent fibre without residual ash; ADL, acid detergent lignin; AOAC, Association of Official Analytical Chemists; BEDN, bacterial and endogenous debris nitrogen; B_0, biochemical methane potential; CEL, cellulose; CH_4, methane; CP, crude protein; CSP, calcium soap of palm fatty acid distillate; DE, digestible energy; CTTAD, coefficient of total tract apparent digestibility; DE-UE/DE, proportion of digestible energy not loss in urine; DM, dry matter; HEM, hemicellulose; aNDFom, stable amylase neutral detergent fibre without residual ash; NH_3, ammonia; OM, organic matter; OP, orange pulp; SF, soluble fibre; TAN, total ammonia nitrogen; TKN, total Kjeldahl N; UDN, undigested dietary nitrogen.

* Corresponding author.
E-mail address: paloma.grebollar@upm.es (P. García-Rebollar).

http://dx.doi.org/10.1016/j.anifeedsci.2015.07.022

$P < 0.001$), with no significant influence on urine N content. These effects resulted in higher N faecal losses, especially those of the undigested dietary origin, without significant effects on potential NH_3 emission. No significant interactions between CSP and OP supplementation were observed for the gaseous emissions measured.

1. Introduction

Intensive pig production is a major contributor to gaseous pollutant emissions. It has been estimated that in the EU it is responsible for 15 and 25% of the total ammonia (NH_3) and methane (CH_4) emissions (EEA, 2014a,b). It is widely recognized that pig slurry characteristics are heterogeneous depending on a number of factors including nutrition. Changes in slurry composition have been associated to gaseous emissions in previous research with modifications of dietary factors, as source and level of fibre (Canh et al., 1998b; Jarret et al., 2012), type of fibre (Triolo et al., 2011; Beccaccia et al., 2015a), level of protein (Canh et al., 1998a; Portejoie et al., 2004; Hernández et al., 2011) and source of protein (Beccaccia et al., 2015b).

Ether extract (EE) is the nutrient with the highest potential to generate CH_4 from the slurry through microbial fermentation (Angelidakis and Sanders, 2004). Beccaccia et al. (2015c) reported that EE content in slurry samples from commercial farms increased CH_4 emission potential, but reduced that of NH_3. However, little is known about the relationships among feed composition, faecal fat concentration and gaseous emissions. Fat content in faeces has two origins: indigestible dietary EE, which is mainly related to the source of fat used in the feed as recognized in several research studies (Cera et al., 1989; Wiseman et al., 1990; Kil et al., 2010) and feeding tables (INRA, 2002; CVB, 2004; FEDNA, 2010), and endogenous losses that are generally associated with microbial synthesis in the gut. Previous studies (Kreuzer et al., 1999; Heimendahl et al., 2010) have found an increment of bacterial content in faeces when including a source of fermentable fibre in the diet, although the effects seem to be lesser when diets were compared at the same dietary neutral detergent fibre (NDF) content (Kreuzer et al., 1999; Beccaccia et al., 2015a). Otherwise, fat addition to the diet might hypothetically affect intestinal microbial activity and digestion efficiency of other dietary constituents.

The aim of the current research was to investigate changes in faecal fat concentration induced through supplementation with two industrial food by-products: calcium soap of palm fatty acids distillate and orange pulp, supplying respectively low digestible fat and fermentable fibre, and how these changes affect gaseous emissions from pig slurry.

2. Material and methods

2.1. Animals and diets

Thirty growing male pigs, progeny of Pietrain × (Landrace × Large White) were divided into three series (batches) of 10 animals each and used subsequently in this study. Average and standard deviation of body weight of pigs in batches 1, 2 and 3 at allocation in metabolism pens were 54.0 (±1.46), 61.4 (±1.44) and 72.5 (±3.16) kg, respectively. A control diet (C) was formulated with ingredients commonly used commercially in diets for growing-finishing pigs (wheat grain, barley grain, wheat bran and soybean meal). Another four experimental feeds were designed by substituting a mixture of wheat grain and calcium carbonate in the control diet (C) with increasing amounts (35 and 70 g/kg) of calcium soap of palm fatty acids distillate (CSP), alone or with further supplementation of 200 g/kg orange pulp (OP) at each level of fat supplementation. The proportions of the other ingredients were also slightly modified to keep essential nutrient composition of diets above the recommendations of FEDNA (2006) for growing fattening pigs. In particular, levels of essential amino acids per unit of net energy (NE) were maintained as similar as possible among the experimental feeds. The analytical composition of the sample used of orange pulp was described in a companion paper (Beccaccia et al., 2015a); the sample of CSP contained 790 g/kg of EE, 190 g/kg of ash and 90 g/kg of Ca, with an estimated NE concentration of 24.5 MJ/kg (FEDNA, 2010). The ingredient and chemical composition of the experimental diets is presented in Tables 1 and 2, respectively. All diets had similar levels of crude protein (CP) and NDF, but the inclusion of CSP resulted in a slight increase in diet NE. Inclusion of OP increased soluble fibre (SF) content.

2.2. Experimental procedures, sample preparation, chemical analyses and emissions measurements

The general methodology used in this experiment has already been outlined in a companion paper (Beccaccia et al., 2015a).

2.3. Statistical analysis

Animal was the experimental unit for all the traits studied. The whole data set derived from the five dietary treatments was analyzed in a one factor analysis of variance as a completely randomized design with trial series, type of diet and its interaction as main effects by using PROC GLM of SAS (2008). The effects of diet were analyzed as a factorial arrangement