Animal Feed Science and Technology 210 (2015) 243–253

Contents lists available at ScienceDirect

Animal Feed Science and Technology

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

Determination of the energy content and amino acid digestibility of double-low rapeseed cakes fed to growing pigs

P.L. Li[a], F. Wu[a], Y.F. Chen[a], J.R. Wang[b], P.P. Guo[a], Z.C. Li[a], L. Liu[a], C.H. Lai[a,*]

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

[b] College of Bio-engineering, Henan University of Technology, Zhengzhou, Henan 450001, China

ARTICLE INFO

Article history:
Received 17 February 2015
Received in revised form 21 August 2015
Accepted 23 October 2015

Keywords:
Amino acids
Digestible energy
Digestibility
Double-low rapeseed cake
Ileal digestibility
Metabolizable energy

ABSTRACT

Two experiments were conducted to determine the digestible (DE) and metabolizable energy (ME) content as well as the apparent (AID) and standardized ileal digestibility (SID) of crude protein (CP) and amino acids (AA) in double-low rapeseed cakes (DLRSC) fed to growing pigs. In Exp. 1, 66 growing pigs (initial body weight (BW): 36.6 ± 4.1 kg) were randomly allotted to 1 of 11 diets ($n = 6$) including a corn-soybean meal basal diet and 10 DLRSC test diets. The basal diet was formulated using corn and soybean meal while the DLRSC test diets contained 192.2 g/kg DLRSC added at the expense of the corn, soybean meal and lysine. In Exp. 2, 9 growing barrows (initial BW: 29.7 ± 3.1 kg) were surgically fitted with a T-cannula in the distal ileum and allotted to a 6 × 9 Youden square design with 6 periods and 9 diets. The diets included a N-free diet containing 689 g/kg cornstarch and 200 g/kg sucrose and 8 test diets which were formulated to include 400 g/kg of one of the DLRSC samples. The chemical composition of the 10 DLRSC samples varied considerably especially for aNDF, ADF, calcium, phosphorus and total glucosinolates. The DLRSC samples had a similar AA composition (CV < 10%) with the exception of lysine (CV = 23.5%). The DE and ME content differed ($P < 0.01$) among the 10 DLRSC samples. On a dry matter basis, the DE (mean 14.51 MJ/kg) and ME content (mean 13.08 MJ/kg) varied from 12.64 to 15.77 MJ/kg and 11.93 to 14.41 MJ/kg, respectively. The apparent total tract digestibility coefficient of gross energy averaged 0.686 ranging from 0.596 to 0.728. The results of Exp. 2 showed the AID of CP and lysine averaged 0.65 and 0.68, respectively. For the indispensible AA in DLRSC, the SID of arginine (mean 0.883) and methionine (mean 0.897) were relatively high. In contrast, the SID of threonine (mean 0.706) and Lys (0.704) were relatively low. The SID of CP and lysine ranged from 0.652 to 0.806 and 0.554 to 0.862, respectively. In conclusion, there were great differences in the chemical composition, energy content and the SID and AID of CP and AA among DLRSC samples. These differences in chemical composition especially the ether extract, fiber and total glucosinolates content may be responsible for the variability often observed in the nutritional value of DLRSC.

Abbreviations: AA, amino acid; ADF, acid detergent fiber; AID, apparent ileal digestibility; ATTD, apparent total tract digestibility; BW, body weight; CP, crude protein; CF, crude fiber; CV, coefficient of variation; DE, digestible energy; DLRSC, double-low rapeseed cake; DLRSM, double-low rapeseed meal; DM, dry matter; EE, ether extract; GE, gross energy; ME, metabolizable energy; aNDF, neutral detergent fiber assayed with a heat stable amylase and expressed inclusive of residual ash; SEM, the standard error of the mean; SID, standard ileal digestibility.

* Corresponding author. Tel.: +86 1062733588; fax: +86 1062733688.
E-mail address: laichanghua999@163.com (C.H. Lai).

http://dx.doi.org/10.1016/j.anifeedsci.2015.10.012
0377-8401/

1. Introduction

World-wide production of rapeseed exceeded 63 million tons in 2013 (USDA, 2014). Double-low rapeseed, also called "canola" in Northern America and Australia, contains less than 2% erucic acid in its oil and 30 μmol/g of glucosinolates in its meal (Raymer, 2002). Rapeseed cake is the product remaining after the oil has been expeller-press extruded from rapeseed. A large quantity of double-low rapeseed cake (DLRSC) is produced each year and is widely used as a source of essential amino acids (AA) in pig (Landero et al., 2012), poultry (Rao et al., 2005; Thacker and Petri, 2009) and cattle feed (McKinnon and Walker, 2009) due to its competitive price and high concentration (350 to 400 g/kg) of protein (Li et al., 2002; Raymer, 2002).

Compared to double-low rapeseed meal (DLRSM), DLRSC is produced without the solvent-extraction. DLRSC contains more than 100 g/kg ether extract (EE) and more than 21.2 MJ/kg of gross energy (GE) (Leming and Lember, 2005), while the EE and GE content in DLRSM ranges from 7 to 19.8 g/kg and from 18.8 to 19.7 MJ/kg, respectively (Li et al., 2015). Therefore, DLRSC is a promising alternative to DLRSM in animal feeds.

DLRSC are produced using many processing techniques in different expeller-pressed crushing plants which may result in great variation in their chemical composition (Keith and Bell, 1991; Spragg and Mailer, 2007), energy content (Toghyani et al., 2014) and digestibility of amino acids (Maison and Stein, 2014). Rapeseed variety, quality and growing environment may also affect the chemical composition of DLRSC (Bell, 1993). Thus the nutritional value of DLRSC may vary widely. For accurate feed formulation, it is so important to determine the energy content and AA digestibility of DLRSC and to have a good knowledge of the variation in their nutritional value. Therefore, the objective of the current study was to determine the chemical composition, energy content and AA digestibility of a wide selection of DLRSC produced using a variety of processing conditions and grown in different environments.

2. Materials and methods

The protocol for this experiment was approved by the Institutional Animal Care and Use Committee of China Agricultural University (Beijing, China). The study was conducted in the Swine Nutrition Research Center of the National Feed Engineering Technology Research Center (Chengde, Hebei, China).

2.1. Source of ingredients

Ten samples of DLRSC were collected from 10 vegetable oil plants located in Hunan, Anhui, and Jiangxi Provinces which are located in the Yangtze River Basin which is the main rapeseed-producing area of China. All the DLRSC samples were produced by expeller-pressed extraction method. Briefly, the double low rapeseed was first cleaned by aspiration to remove impurities, then cooked in the cookers which were heated using water steam or thermal oil and finally pressed in a screw press, allowing the rapeseed oil to be extruded out and rapeseed cakes to be produced. The chemical composition of the collected DLRSC is shown in Table 1.

2.2. Experiment 1

Experiment 1 was conducted to determine the DE and ME content of the DLRSC. Sixty-six crossbred barrows (initial body weight (BW): 36.6 ± 4.1 kg; Duroc × Landrace × Yorkshire), were randomly allotted to 1 of 11 diets including one corn-soybean meal basal diet and 10 DLRSC test diets (Table 2). The test diets contained 192.2 g/kg DLRSC which replaced 20% of the energy supplying ingredients in the basal diet. L-lysine·HCl was added to all diets to obtain a balanced AA composition. Vitamins and minerals were included to meet or exceed the requirements for growing pigs as recommended by NRC (1998). The analyzed composition of the experimental diets is shown in Table 3.

The pigs were individually placed in stainless-steel metabolism crates (1.4 m × 0.7 m × 0.6 m) equipped with a water nipple and a feeding trough and housed in an environmentally controlled room (22 ± 2 °C). The pigs were fed 4% of their BW daily (Adeola, 2001). The daily feed allotment was divided into 2 equal meals at 08:30 and 15:30 h. Pigs had free access to water throughout the experiment. Feed refusals and spillage were collected before feeding to be dried, weighed and recorded.

Individual pig body weight was obtained at the beginning of the experiment. Pigs were adapted to their diets for 7 days followed by a 5-day total collection of feces and urine. Feces were placed in plastic bags (one bag per pig) as soon as they appeared in the metabolism crates and were immediately stored at − 20 °C. A bucket containing 50 ml of 6 N HCl was used to collect urine. Each day, the volume of collected urine was measured and 10% of the daily urinary collection was filtered and transferred into a screw-capped bottle and then stored at −20 °C until needed for analysis. At the end of the experiment, feces and urine were thawed, pooled by pig, homogenized and sub-sampled. Before analysis, fecal subsamples were dried for 72 h in a 65 °C drying oven and ground through a 1-mm screen.