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Amino acid digestibility in rice co-products fed to growing pigs

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ABSTRACT

The global production of paddy rice exceeds 700 million tons per year. The primary objective of rice production is to produce polished white rice for human consumption, but in this process, several co-products that may be fed to livestock are also generated. The objective of this experiment was to determine the coefficient of ileal apparent digestibility (CIAD) and the coefficient of ileal standardized digestibility (CISD) of crude protein (CP) and amino acids (AA) in 2 sources of full fat rice bran (FFRB), 1 source of defatted rice bran (DFRB), and in broken rice when fed to growing pigs. Seven finishing pigs with an average initial body weight of 70.1 ± 6.3 kg were used. Pigs were surgically fitted with a T-cannula in the distal ileum. Animals were allotted to a 7 × 7 Latin square design with 7 diets and 7 periods. Seven diets were prepared, but 1 diet was unrelated to this experiment; therefore only 6 diets were used in this experiment. One diet was based on bakery meal, and 1 diet was based on broken rice. Three additional diets were formulated by mixing bakery meal and each of the 2 sources of FFRB (FFRB-1 and FFRB-2) or DFRB. The last diet was an N-free that was used to estimate the basal ileal endogenous losses of CP and AA. The CIAD of CP and AA in bakery meal and broken rice was calculated using the direct procedure, but the CIAD of CP and AA in both sources of FFRB and in DFRB was calculated using the difference procedure. The CIAD and CISD of CP and AA in broken rice were greater ($P < 0.05$) than the CIAD and CISD of CP and AA in all other ingredients. The CIAD of the average of indispensable AA was greater ($P < 0.05$) for broken rice and less ($P < 0.05$) for DFRB, than for the 2 sources of FFRB. The CISD for the average of indispensable AA in broken rice (0.949) was greater than in FFRB-1 (0.862), FFRB-2 (0.850), and DFRB (0.817), but there were no differences between the 2 sources of FFRB, and the average CISD of indispensable AA in DFRB was less ($P < 0.05$) than in the other ingredients. The concentrations of CISD CP and indispensable AA in DFRB were greater ($P < 0.05$) than in all other ingredients. In conclusion, the CIAD and CISD of CP and AA in broken rice was greater than in FFRB and DFRB, but the greater concentration of CP and AA in FFRB and DFRB result in greater concentrations of CISD CP and AA in FFRB and DFRB than in broken rice.

Abbreviations: AA, amino acids; AEE, acid-hydrolyzed ether extract; CIAD, coefficient of ileal apparent digestibility; CISD, coefficient of ileal standardized digestibility; CP, crude protein; CTTAD, coefficient of total tract apparent digestibility; DFRB, defatted rice bran; DM, dry matter; FFRB, full fat rice bran; GE, gross energy; SEM, standard error of the mean.

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1. Introduction

Rice is the main source of carbohydrates for humans worldwide, but its use in pig feeding is limited because of relatively high price and limited availability (Vicente et al., 2009). The global production of rice is approximately 718 million tons per year (FAOSTATS, 2012), and the majority is used for production of white polished rice. When rice is milled, 60–72% of the grain is recovered as polished rice, which is used for human consumption, but the remaining 28–35% are co-products, which may be used in animal feeding. The co-products include rice hulls, rice bran, and broken rice (Singh et al., 2013). Rice hulls constitute about 20% of the weight of the rough rice, but contain large quantities of lignin and silica and have low nutritional value (Serna-Saldívar, 2010). Broken rice, also called brewers rice, are kernels of polished rice that are 25% or less of the original length of the grain and are used for production of rice meal, brewing or other fermented products, or for animal feeding (USA Rice and Federation, 2013). Broken rice is high in starch, low in fiber, fat, and CP, and has been used in diets for nursery pigs without detrimental effects on growth performance, but improved intestinal health has been reported (Vicente et al., 2009). Rice bran is the brown layer of dehulled rice and includes several sub layers within the pericarp and aleurone layers. Rice bran is categorized as full fat rice bran (**FFRB**) or defatted rice bran (**DFRB**) that contains approximately 140 g/kg and 35 g/kg ether extract, respectively (NRC, 2012). The concentration of crude protein (**CP**) ranges from 150 g/kg in FFRB to 173 g/kg in DFRB (NRC, 2012). Different procedures used in rice milling may negatively affect the digestibility and availability of amino acids (**AA**) and CP by growing pigs (Kaufmann et al., 2005), but there is limited information about the ileal digestibility of AA in rice co-products. Therefore, the objective of this research was to determine the coefficient of ileal apparent digestibility (**CIAD**) and the coefficient of ileal standardized digestibility (**CISD**) of CP and AA in 2 sources of FFRB (**FFRB-1 and FFRB-2**), 1 source of DFRB, and in broken rice when fed to growing pigs.

2. Materials and methods

The protocol for this experiment was reviewed and approved by the Institutional Animal Care and Use Committee at the University of Illinois. Four rice co-products were evaluated: 2 sources of FFRB, 1 source of DFRB, and broken rice (Table 1). Broken rice was sourced from Consumers Supply Distributing, North Sioux City, SD; DFRB and FFRB-1 were donated by RiceBran Technologies, Scotsdale, AR; and FFRB-2 was sourced from Triple Crown Nutrition, Inc., Waynata, MN.

2.1. Animals and housing

Seven finishing pigs that were the offspring of F-25 females that were mated to G-Performer males (Genetiporc, Alexandria, MN) with an average initial body weight of 70.1 ± 6.3 kg were used. Pigs were surgically fitted with a T-cannula in the distal ileum (Stein et al., 1998) when they had a body weight of approximately 25 kg, and all pigs had been used in a previous experiment before being assigned to this experiment. Animals were allotted to a 7 × 7 Latin square design with 7 diets and 7 periods. Pigs were housed in individual pens (1.2 m × 1.5 m) in a temperature controlled room. Pens had smooth, plastic-coated sides, and a fully slatted tribar metal floor; a feeder and a nipple drinker were installed in each pen. Pig weights were recorded at the beginning of each period to calculate feed allowance during the following period.

2.2. Diets and feeding

Seven diets were prepared (Table 2), but 1 diet was unrelated to this experiment; therefore, only 6 diets were used in this experiment. One diet was based on bakery meal (17.6 MJ gross energy (**GE**) and 140.3 g/kg CP) and 1 diet was based on broken rice (17.5 MJ GE and 69.8 g/kg CP). Three additional diets were formulated by mixing bakery meal and each of the 2 sources of FFRB (FFRB-1 and FFRB-2) or DFRB. These diets contained 17.6, 17.7, and 17.4 MJ GE and 122.4, 130.8, and 130.4 g/kg CP, respectively). The last diet was an N-free diet (17.5 MJ GE and 2.6 g/kg CP) that was used to estimate the basal ileal endogenous losses of CP and AA. All diets contained vitamins and minerals in concentrations that exceeded the requirements for growing pigs (NRC, 2012). Chromic oxide (4.0 g/kg) was added to all diets as an indigestible marker.

Because all diets contained AA in quantities below the requirements for growing pigs (NRC, 2012), an AA mixture was prepared (Table 3). During the initial 5 days of each period, 150 g of this mixture was provided every day to each pig with 75 g provided at each feeding.

Pigs were fed twice daily at a level of 3 times the maintenance energy requirement (i.e., 0.82 MJ metabolizable energy per $kg^{0.60}$; NRC, 2012), and the average daily energy intake during the experiment was 25.5 MJ metabolizable energy. Water was available at all times throughout the experiment.

2.3. Sample collection

Each period consisted of 5 d of adaptation to the diets followed by 2 d of ileal digesta collection. Ileal digesta collection was initiated at 0800 and ceased at 1600 h each day. For collection of samples, a plastic bag of 232 ml was attached to the cannula barrel using a cable tie. Bags were removed when they were filled or every 30 min and stored at −20 °C to prevent bacterial degradation of AA.